Committee 8 C

Imaging and other Investigations

Chairman

W. ARTIBANI (ITALY)

Members

J.T. ANDERSEN (DENMARK),

J.B. GAJEWSKI (CANADA),

D.R. OSTERGARD (USA),

S. RAZ (USA),

A. TUBARO (ITALY)

Consultants

V. KHULLAR (UK),

P. KLARSKOV (DENMARK),

L. RODRIGUEZ (USA)

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W. ARTIBANI,

J.T. ANDERSEN, J.B. GAJEWSKI, D.R. OSTERGARD, S. RAZ, A. TUBARO,
V. KHULLAR, P. KLARSKOV, L. RODRIGUEZ

INTRODUCTION

The committee was charged with reviewing and updating the chapter Imaging Techniques and Other Investigations in Urinary Incontinence (W. Artibani, J.T. Andersen, D.R. Ostergard, C.E. Constantinou, J.B. Gajewski, V.N. Nitti, P. Klarskov, G. Schaer, A. Tubaro: Incontinence, Health Publication Ltd, 1999, p. 401-445).

This revision/update was performed by the committee members and consultants, and then collegially processed to obtain a consensus.

The different techniques are categorized as imaging techniques, endoscopy, pad testing, and other investigations (urinalysis, chemical tests and tissue analysis).

They were analyzed taking into account various viewpoints as follows:

• Age (children, adults, and elderly)

• Gender

• Type of urinary incontinence:

- extra urethral/ per urethra
- congenital / acquired
- neurogenic / non-neurogenic
- stress / urge / mixed / chronic retention with incontinence/functional /other types
- postvoid dribbling

• Upper and lower urinary tract

On the basis of a peer reviewed literature review and expert opinion, the role of imaging techniques and other investigations was outlined, when possible, with regards to diagnosis, measurement of severity, indications for treatment, prognostic value, monitoring and follow-up, cost-effectiveness ratio, outcome evaluation and research interest.

For each imaging technique or investigation, general recommendations and suggested research areas are indicated.

Levels of evidence are difficult to apply to the subject of this chapter since prospective randomised trials are rarely used. We tried to follow ICUD's recommendation for issues related to assessment and investigation, by evaluating each test for technical perfomance, diagnostic performance and clinical relevance.

We used the following revised levels of evidence.

High Level Evidence : More than one prospective, comparative, blindly evaluated, trial with acceptable entry criteria, adequate statistical power, and data analysis. (Gold standard imaging techniques should be compared to new imaging modalities).

Intermediate Level Evidence: A single prospective, comparative, blindly evaluated trial with the same requirements stated for High Level, or multiple clinical trials which do not meet all the requirements for High Level (for example some are not blindly evaluated).

Low Level Evidence: Non prospective, and/or non comparative trials or prospective, comparative clinical trials with documented design flaws (e.g. insufficient patient numbers, inadequately defined entry criteria, or inadequate statistics).

No Evidence: No clinical trial data or information limited to single institution retrospective series, abstracts, or meeting presentations.

In regards with recommendations, we also defined the degree of Committee agreement as follows:

Unanimous agreement: All Committee members agree on the recommendation.

Significant Majority: At least 75 % of the Committee agree on the recommendation.

Majority: More than one-half of the Committee agrees on the recommendation. In this case, the minority opinion should be stated in the report.

No agreement.

There are places in the chapter where the degree of agreement of a recommendation is specified without indicating levels of evidence. This is the case when unanimously agreed recommendations could not be supported by data, and there should have been paradoxically a mark of no evidence or low level evidence. In case of a recommendation with high level evidence, unanimous agreement is implicit and was not specified.

A. IMAGING OF THE UPPER URINARY TRACT

I. BACKGROUND

Urinary incontinence is classically thought of as involuntary loss of urine "per uretram" as a result of sphincter and/or bladder dysfunction. Extra-urethral urinary incontinence may occur as a result of congenital anomalies such as ectopic ureters (inserting in the female distal urethra or vagina) or traumatic conditions such as fistula. Furthermore, lower urinary tract dysfunction, which may be a cause for incontinence, might compromise the transport of urine from the kidneys to the bladder resulting in hydronephrosis and renal damage. The relationship between high bladder storage pressure and renal deterioration has been well established [1].

Such damage is usually detectable at various stages by imaging of the kidneys and/or renal function tests. There are two other conditions related to urinary incontinence which may endanger the upper tract: one is chronic retention with incontinence, and the second is the presence of severe urogenital prolapse which may cause angulation of the ureters at the level of the uterine arteries with consequent hydroureteronephrosis in as many as 30% to 40% of patients [2] (Figure. 1 a,b).

II. INDICATIONS

Generally speaking, there is no need for upper tract imaging in cases of urinary incontinence with no neurological etiology.

Upper urinary tract imaging becomes an important part of the evaluation of the incontinent patient when extra-urethral urinary incontinence or potentially dangerous lower urinary tract dysfunction are known or suspected. Thus the objectives used for upper tract imaging in the incontinent patient are the following:

1. Evaluation of the ectopic ureter or ureterovaginal fistula as a cause of urinary incontinence

2. Evaluation of the kidneys in cases where urinary incontinence is related to bladder dysfunction with high storage pressures (e.g. in neurogenic voiding dysfunction, chronic retention with overflow or low-compliance bladders)

3. Exclusion of hydronephrosis in cases of urinary incontinence associated with severe uterine prolapse (Figure 2 a,b,c,d)

III. MODALITIES

The most commonly used upper tract imaging modalities include intravenous urography (IVU), ultrasonography, computerized tomography (CT scan), magnetic resonance imaging (MRI), and isotope scanning.

None of these tests have been evaluated for specificity, sensitivity, predictive value or reproducibility in connection with the diagnosis and management of urinary incontinence. There are large geographical variations concerning availability of equipment, local expertise and traditions.

Therefore, the examinations are summarized on the basis of literature review and expert opinion, and only special points with respect to urinary incontinence are mentioned.

IV. INTRAVENOUS UROGRAPHY

Intravenous urography or intravenous pyelography (IVP) is the original radiographic examination of the upper urinary tract. Successful examination is dependent upon adequate renal function. Renal dysfunction, obstruction, congenital anomalies, fistula, stones and tumors may be detected.

IVU is the appropriate first study when ureteral ectopia is suspected. Delayed films and tomography are important because the renal unit or moiety associated with an ectopic ureter is often poorly functioning. In fact, IVU is sometimes unable to detect a small, malfunctioning moiety associated with a duplication and ectopic ureter or a poorly functioning or abnormally located kidney with a single ectopic system [3 - 5]. In such cases where the diagnosis of ectopia is still suspected after IVU, another imaging modality such as CT, MRI (Figure 3 a,b) or isotope scanning [6 - 8] should be considered.

IVU is the appropriate first imaging study when uretero-vaginal fistula is suspected, usually after pelvic surgery. Typically, one sees ureteropyelocaliectasis proximal to the level of the fistula. This finding has been reported in 84-92% of cases [9, 10]. Sometimes extravasation can be seen. Confirmation of the presence of the fistula, its size and exact location is often obtained with retrograde ureteropyelography.

V. ULTRASONOGRAPHY

Ultrasonography is an excellent tool for imaging of the upper urinary tracts. It is totally non-invasive, and successful imaging of the kidneys is independent of renal

Figure 1a: Procidentia uteri.

Figure 1 b: IVU: bilateral hydronephrosis. Left kidney is in sacral ectopia.

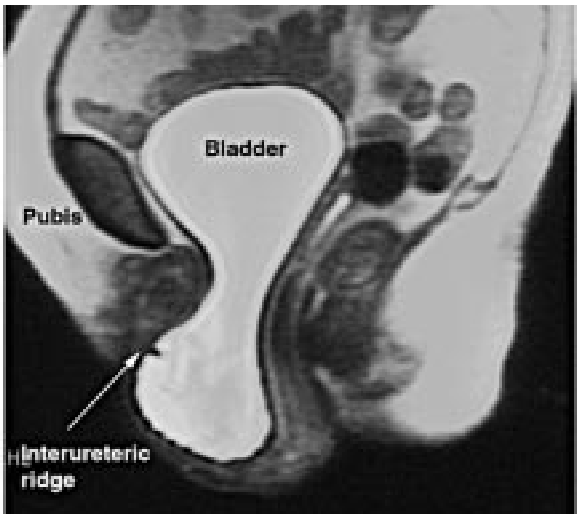


Figure 2 a: MRI: complete urogenital prolapse.

Figure 2-b: MRI: ureteral dilation

Figure 2-c: MRI: ureteral dilation

Figure 2-d:MRI bilateral hydronephrosis

Figure 3 a : MRI diagnosis of ureteral ectopia

Figure 3 b : MRI diagnosis of ureteral ectopia: sagittal view

function. Ultrasound can be used to assess many features of renal anatomy including renal size and growth, hydronephrosis, segmental anomalies, stones and tumors. In the evaluation of the patient with lower urinary tract dysfunction, the detection of hydronephrosis is extremely important and may be an indication of vesico-ureteral reflux or obstruction. However, no correlation exists between the degree of dilatation and the severity of obstruction. Also renal blood flow can be detected by the doppler technique. Because ultrasonography can not predict function or degree of obstruction or reflux, other imaging modalities are often used after hydronephrosis is initially diagnosed by ultrasound.

Ultrasound is an excellent tool to follow the degree of hydronephrosis over time or the response to treatment.

VI. COMPUTERIZED TOMOGRAPHY

Computerized Tomography scan (CT) provides useful information about the anatomy of the upper urinary tract. Information can be independent of renal function, however, the addition of intravenous contrast can highlight specific anatomic characteristics (dependent upon renal function). CT scan can be used as an alternative to ultrasonography or IVP, and in many cases provides additional information, although at a higher cost. Several authors have reported the use of CT scan to detect ectopic ureter, in cases where the diagnosis is suspected, despite a normal IVU and ultrasound [11]. In these cases the small size and poor function of the ectopic moiety made diagnosis difficult by IVU.

VII. MAGNETIC RESONANCE IMAGING

Magnetic Resonance Imaging (MRI) offers some of the same benefits as CT in the evaluation of the upper urinary tracts. It has the advantage over CT in that all planes of imaging are possible. MRI may play an increasing role in the evaluation of hydronephrosis and urinary tract anomalies in the future. Its usefulness has recently been described in the diagnosis of ectopic ureter [12, 13].

VIII. ISOTOPES

Isotopes are used primarily to examine functional characteristics of the upper urinary tract. Isotope scanning can be used to evaluate renal morphology and location. Renography is used to examine the differential function of the two kidneys as well as how they drain. There are many physiological factors and technical pitfalls that can influence the outcome including the choice of radionucleotide, timing of diuretic injection, state of hydration and diuresis, fullness or back pressure from the bladder, variable renal function and compliance of the collecting system [14 - 16].

Diuresis renography with bladder drainage is recommended when obstructive uropathy is suspected [17]. Renal scintigraphy may be useful in the evaluation of ectopic ureters in association with hypoplastic kidneys [18].

IX. CONCLUSIONS AND RECOMMENDATIONS

1. Imaging of the upper urinary tract is NOT indicated in the evaluation of non-neurogenic stress, urge or mixed urinary incontinence. (***Unanimous agreement***)
2. Imaging of the upper urinary tract is indicated in cases of (***Unanimous agreement***):

a) neurogenic urinary incontinence with high risk of renal damage (due to high detrusor pressure, e.g. myelodysplasia, spinal cord injury, and low compliance bladders) (***High Level Evidence***)

b) chronic retention with incontinence (***Intermediate Level Evidence***)

c) untreated severe urogenital prolapse (***Low Level Evidence***)

d) suspicion of extra-urethral urinary incontinence by upper tract anomaly (***High Level Evidence***)

3. The choice of the imaging techniques and their sequence depend on the clinical question and their availability. The least invasive techniques should be preferred and should precede the more invasive, also taking into consideration cost effectiveness. (***Unanimous agreement***)

X. SUGGESTED RESEARCH AREAS

1. Prevalence of upper tract deterioration in various urinary incontinence populations
2. Natural history of upper tract damage
3. Relation between upper tract dilation, renal damage and bladder function

B. LOWER URINARY TRACT (LUT) IMAGING

Radiological visualization of the position and morphology of the bladder, urethra and pelvic floor has been used mainly in connection with management of female urinary incontinence. Additional aims are to demonstrate leakage, to locate infravesical obstruction, vesicoureteral reflux, diverticula, fistula, stones, and tumours.

In males the purpose of voiding cystourethrography has been mainly to locate infravesical obstruction [1, 2]. In children the diagnosis and classification of reflux and diagnosis of posterior urethral valves have been the primary goals [3]. MRI may be an alternative [4].

Positive-pressure urethrography has been designed only for the diagnosis of female urethral diverticula and was shown to be more sensitive than voiding cystourethrography [5, 6, 7].

B-I. IMAGING IN FEMALE URINARY INCONTINENCE AND PELVIC FLOOR DYSFUNCTION

I. FEMALE CYSTOURETHROGRAPHY

1. Background

Aspects of the history and methodology of cystourethrography in females had been reviewed by Olesen [8]. Voiding cystourethrography with lateral projection was first done by Mikulicz-Radecki in 1931 [9]. Stevens and Smith in 1937 [10] introduced a metallic bead chain into the urethra, and in 1956 Ardran, Simmons and Stewart [11] reported on a cinematographic technique with contrast media also in the vagina and rectum. During the sixties and seventies several reports emerged on combined fluoroscopy and pressure and flow recordings [12 - 16].

2. Methodology (projection, positioning and exposures)

Frontal and oblique projections are inferior to a straight lateral projection in diagnosing bladder descent, and in differentiating between different types of displacement. A seated position is recommended for micturition in female patients, because micturition standing or lying will increase the embarrassment and thereby the bias of the examination [8]. However, lateral projection necessitates high radiation doses with sufficiently high kV, as the central x-ray beam must penetrate the trocanteric regions and further because the urethrovesical junction sometimes is overshadowed by the lateral parts of the bladder. The position and mobility of the urethrovesical junction and leakage are supposed to be influenced by the filling volume as has been demonstrated on ultrasonography [17] and leak point pressure measurements [18]. However, in voiding cystourethrography the bladder is filled to capacity. Addition of a urethral bead chain or catheter and vaginal contrast improve the visualisation of the urethra, bladder neck and trigone. Contrast in the rectum is not necessary for urinary incontinence purposes.

Exposures at rest should be supplemented with provocative manoeuvres (coughing, straining, and squeezing) and micturition. Coughing and straining differs. Straining might be associated with relaxation or contraction of the pelvic floor, and the imaging can change accordingly. During coughing there is a reflex contraction of the pelvic floor, but coughs are of short duration and difficult to catch on spot films. Bladder suspension defects were diagnosed at rest in 49% of 420 examinations, while coughing and micturition disclosed a further number of 20% and 4% respectively [8]. Squeezing can demonstrate pelvic floor awareness and contraction [19].

3. Combined imaging and urodynamics

Videourodynamics has been by some regarded as the "gold standard" in the evaluation of lower urinary tract dysfunction [20]. However, it is controversial whether urodynamic and radiographic testing should be performed simultaneously or on separate occasions. Urodynamic examinations must be repeated several times to obtain reproducibility [21, 22], and the more parameters studied the more complicated the examination will be with a corresponding risk of bias. Reproducibility of the combined examination has not been assessed, and, further, the radiation dose has to be considered [10, 15, 23, 24]. Nevertheless simultaneous videomonitoring along with tracings of pressure and urine flow rate are important means to be sure that the exposures are made at appropriate moments so that the radiographs can be representative of the various functional states [8, 13, 25, 26].

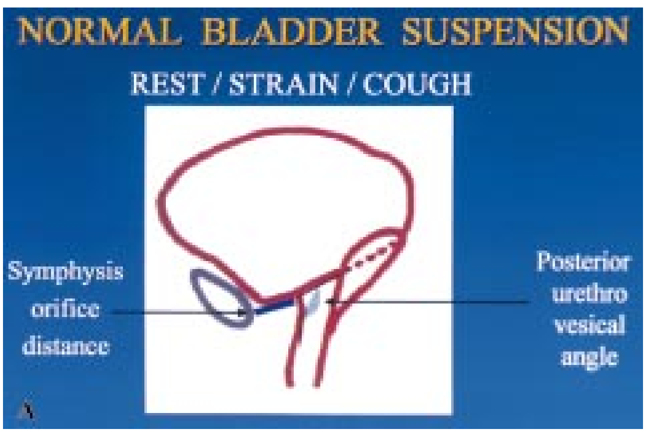
4. Normal and defective bladder support

The normal resting bladder has a smooth surface. The position of the internal urethral orifice is situated between the anterior and the middle third of the base just above a horizontal line through the lowermost part of the symphysis. The base is flat and slopes upwards and backwards. The urethra is straight and runs downwards and forwards giving rise to an angulation with the bladder base. The vagina lies approximately 1.5 cm behind the urethra and the trigone following a parallel course. On coughing and straining (Figure 4a) there might be a minor movement and curvation downwards, but no essential changes should occur. Squeezing should cause changes in the opposite direction. During voiding (Figure 4b) the bladder base is usually lowered about 1 cm, the angulation between the urethra and the trigone is straightened, making a funnelled appearance of the proximal urethra and the bladder base, the bladder contour is rounded and a fine sawtooth irregularity of the mucosa becomes visible above the trigone. Post voiding pictures should be interpretated with caution.

Different angles, planes, distances and morphological criteria have been used to discriminate between normal and defective bladder support.

The following parameters have been assessed for reliability:

1. The posterior urethrovesical angle (PUV) is defined by lines along the posterior urethra and the trigone [27]. Cut off values were usually 115° or more [28, 29].
2. The urethral inclination is between the proximal urethral axis and the vertical plane, which is a plane outside the patient and, therefore, the angle also varies with pelvic inclination. In Green type I and type II descent the angle is less or more than 45° respectively [30].
3. The urethropelvic angle (UP) is measured during voiding as the anterior angle between a line through the middle of the internal urethral orifice and the urethral knee and a line through the posterior surface of the symphysis through the lowermost part of the obturator foramen closest to the film. In normals the mean UP is about 95° and the cut off point for bladder descent are values below 70° [8].



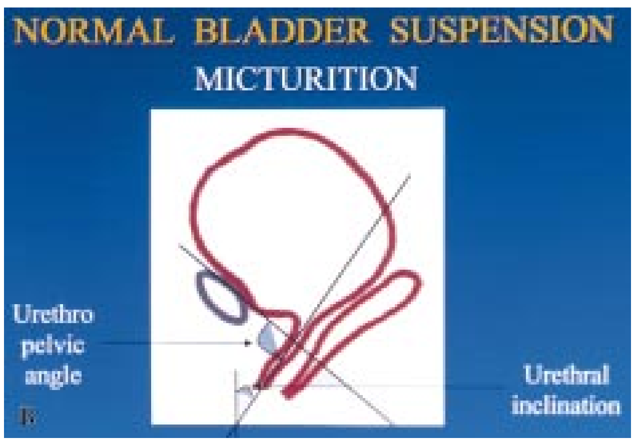


Figure 4 : Female Cysto-urethrography 1a: normal appearance on coughing, straining and squeezing 1b: normal appearance on voiding

4. Symphysis orifice distance (SO) is measured at rest as the distance on a horizontal line from the symphysis to the internal urethral orifice. Normal values are 31 +- 6 mm (mean +- SD) and values less than 20 mm are the cut off points for descent [8]

Funneling of the proximal urethra, flatness of the bladder base (both anterior and posterior to the internal urethral orifice) and the most dependent portion of the bladder base (the urethrovesical junction or a point posterior to that) are important qualitative parameters estimated on straining films [28]

Anterior bladder suspension defects or bladder base insufficiency (BBI) Figure 5 is defined as SO < 20 mm with a normally positioned vagina at rest, during coughing or micturition and/or funneling of the bladder base at rest or with coughing. The insufficiency can be graded 1-3 [8] which corresponds to Green's type I descent [30]. The supportive defect is supposed to be in the fascial and ligamentous system and their abnormal detachments (eg., paravaginal defects).

Posterior bladder suspension defects [8] Figure 6 are defined as a posterior-inferior bladder displacement and a UP of less than 70°. This corresponds to Green's type II [30]. In trigonocele (Figure 7) only the trigone and posterior part of the bladder is involved. The supportive defect is supposed to be in the muscular pelvic floor, that is, the pubo-vesical part of the pubococcygeus muscle or in paravaginal detachment.

5. Reliability

Reliability depends on both accuracy and reproducibility.

The accuracy of the previously mentioned radiological criteria have been measured by comparing the test results with a final true diagnosis of genuine stress incontinence or a "gold standard" and expressed as specificity and sensitivity or as predictive values. The crux of the matter is that the diagnosis of stress urinary incontinence is controversial and might be based on subjective criteria, urodynamic tests, or measurement of leakage. Even radiological criteria have been included in the diagnosis.

Reproducibility has not been measured as test-re-test agreement, but intra- and inter-observer variation has been calculated and also adjusted for expected chance agreement (kappa coefficient). The predictive values and the kappa coefficient are supposed to depend on the prevalence [31], and therefore, comparison between different materials are difficult.

6. Specificity, sensitivity and predictive values for the diagnosis of stress incontinence and post-operative results

There is agreement in the literature that cystourethrography can not discriminate between stress incontinence and continence [29,32 - 34]. The specificity of 5 radiological parameters on static bead chain cystourethrography was 44-76% and the sensitivity 53-100% [35,36]. Neither was the degree of stress incontinence correlated to the type or degree of suspension defects [19,37,38]. The predictive values of demonstrating a bladder suspension defect PV-pos was 0.70 (95% c.l. 0.62-0.78) and normal appearance PV-neg was 0.52 (95% c.l. 0.41-0.63) on voiding colpo-cystourethrography [39,30]. In a later publication on 159 women PV-pos was 0.56 and PV-neg 0.74 [34].

Further, it is not possible to distinguish postoperative failures from success [8,19,31,33,36,40 - 43]. Colposuspension gives rise to a typical configuration, vaginal repair was usually not detectable on cystourethrography, and pelvic floor training improved the squeezing effect, but not the suspension defect [19].

7. Reproducibility

The observer variation has been evaluated in four university uro-gynecological units [19,28,38,44] (Table 1)

The inter-observer agreement was 43-79% and the intra-observer agreement was 53-99%. These figures are in the same range as has been found for other diagnostic tests [31]

8. Comparison of cystourethrography and ultrasonography

Static bead chain cystourethrography has been compared with transrectal [36] and perineal ultrasonography [45,46] and voiding colpo-cystourethrography has been compared with perineal ultrasonography [47]. The findings correlated well regarding bladder beck position and mobility, PUV, urethral inclination, SO distance and rotation angle.

Specificity, sensitivity and interobserver agreement were also comparable for the two methods. All the authors seem to prefer the sonographic modality because the imaging study can be performed at the same time as the physical examination. This has also been the case in men with neuromuscular dysfunction [2]. Simple and extensive funnelling is more easily imaged in upright patients during cystourethrography than in the supine position frequently used for ultrasound studies [48].

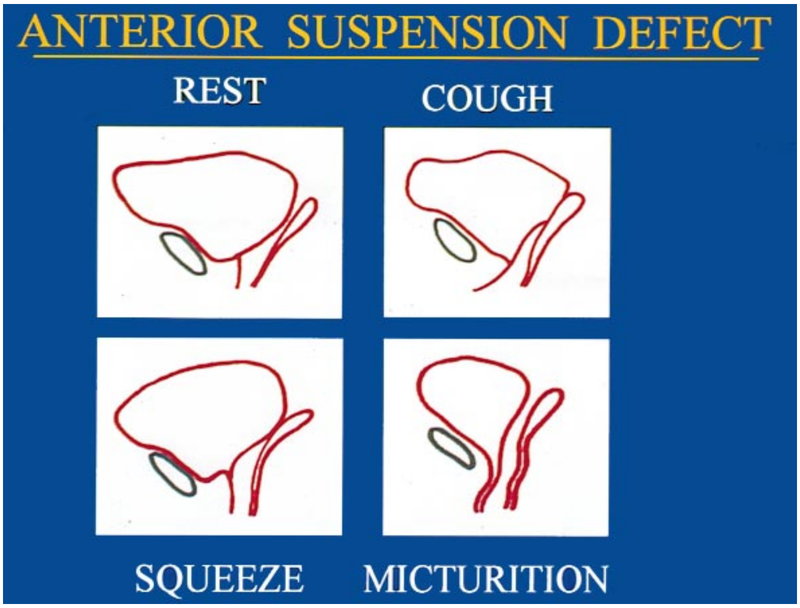


Figure 5 : Female Cysto-urethrography. Anterior bladder suspension defect

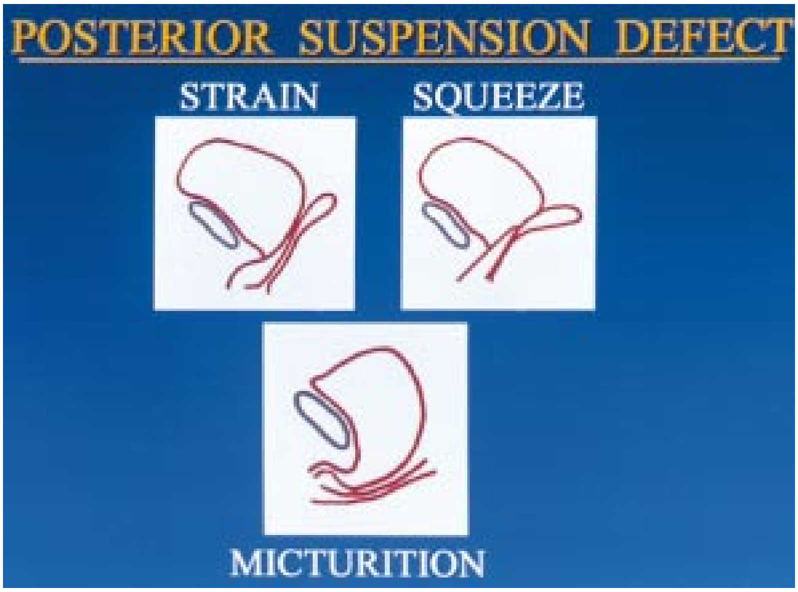


Figure 6 : Female Cysto-urethrography. Posterior bladder suspension defect

Figure 7 : Female cystourethrography: Trigonocele: The trigone herniates through the anterior vaginal wall.

Table 1 : Inter- and intra-observer variation (agreement) on cystourethrography in females with urinary incontinence.

Type of examination, patients and observers	Inter-observer variation	Intra-observer variation
Bead-chain (1) stress & urge incont. n°92 3 observers on 5 landmarks	45.8-80.7 % VCCU 2	
VCCU (2) stress incontinence n° 52 1 observer on type of descent	79% 95% c.l. 65-89	
VCCU (3) stress incontinence n° 29 2 obervers on type of descent	70% 95% c.l. 75-89	53 95% c.l. 27-78
VCCU (4) n° 93 stress & urge incont. 6 observers on type of descent	43-60% kappa 20-39%	72-99% kappa 57-98%

Legend Table 1:
1: static bead-chain cystourethrography with straining [28]. The 5 landmarks were the posterior urethrovesical angle, urethral inclination, funneling of the proximal urethra, flatness of the bladder base and most dependent position of the bladder base.
2: voiding colpo-cystourethrography (VCCU) at rest and with coughing, straining, micturition and squeezing; one observer against original diagnosis (that is, normal appearance or anterior, posterior or combined suspension defects) made by a few senior radiologists [19].
3: voiding colpo-cystourethrography at rest and with coughing, straining, squeezing and micturition. Possible diagnoses were: normal appearance or anterior, posterior or combined descent respectively [44].
4: voiding colpo-cystourethrography at rest, coughing, with holding and voiding. Possible diagnoses were: normal appearance and anterior or posterior descent respectively [38].

9. Comparison of cystourethrography and MRI

Magnetic resonance imaging and lateral cystourethrography was compared in 27 women with urinary incontinence and bladder descent [49] and with colpocystorectography in 12 women or with bead-chain cystourethrography in 20 women in a prospective study [50]. The findings on MRI were equivalent to that obtained with colpocystorectography and superior to cystourethrogaphy in diagnosing rectoceles. Bias produced by difference in study position must also be considered when MRI and cystourethrography is compared.

10. Conclusions

The role of cystourethrography in the evaluation of female urinary incontinence is not yet established.

Defective bladder support can be diagnosed on voiding cystourethrography with a reliability comparable with other diagnostic tests. [***High Level Evidence***].

Dependent on local facilities the method might be considered if the choice of a surgical procedure is based on type and degree of supporting tissue insufficiency and possibly if new procedures are evaluated for the ability to restore this insufficiency. [***Low Level Evidence***].

The method can not be recommended for the diagnosis or classification of urinary incontinence. [***High Level Evidence***].

11. Recommendations

Cystourethrography is NOT indicated in primary uncomplicated stress, urge or mixed female urinary incontinence [***High Level Evidence***].

Cystourethrography may be a reasonable option in the preoperative evaluation of complicated or recurrent female urinary incontinence [***Low Level Evidence, Unanimous agreement***].

12. Suggested research areas

Standardization of technique, parameters and interpretation of cystourethrography

Possible value of cystourethrography in the evaluation of pelvic floor dysfunction (correlation of imaging to pelvic floor physical examination and to clinical outcome following therapy)

II. ULTRASOUND OF THE LOWER URINARY TRACT AND PELVIC FLOOR IN FEMALE URINARY INCONTINENCE

1. BACKGROUND

Since the 1980's reports on ultrasound evaluation of the lower urinary tract indicate that ultrasound is a valuable alternative to other imaging techniques. Studies comparing sonographic and other imaging techniques demonstrated the suitability of ultrasound [1 - 3]. These studies and the growing experience with pelvic floor sonography enabled the introduction of ultrasound into numerous urodynamic units as a helpful and highly informative assessment. Recent advancements in 3D ultrasonography opened new perspectives in the evaluation of incontinent female patients such as quantification of female urethral sphincter thickness and mass as well as evaluation of the urethra's submucosal vascular plexus [4 - 6]. A review of the international literature on urogynecology imaging shows that ultrasound studies have been predominated in recent years.

2. METHODOLOGY

Lower urinary tract ultrasound is an investigational evaluation for the study of female urinary incontinence and prolapse which allows morphological and functional documentation.

In principle two techniques should be differentiated (Figure 8):

endosonographic applications: vaginal and rectal sonography;

external applications: perineal and introital sonography.

Vaginal ultrasound is performed by introducing a linear or endfiring probe into the vagina (5 and 7.5 MHz) while ***rectal*** ultrasound uses the same probe rectally [7,8]. ***Perineal*** sonography is performed with a curved array ultrasound probe placed on the perineum (3.5 and 5 MHz) and ***introital*** ultrasound with a vaginal sector scanner placed between the labia minora (5 and 7.5 MHz) [9 10].

The decision in favour of one of the methods depends above all on local expertise and availability of the ultrasound probe although a vaginal approach has been considered to interfere with bladder neck and urethra anatomy and function [11,12]. Transrectal imaging, although invasive, does not influence urodynamic parameters during cystometry [13].

3D ultrasound imaging of the female urethra is performed with a linear 7.5 MHz probe using a transvaginal approach. Evaluation of the urethra's submucosal vascular plexus by colour Doppler can be performed by introital sonography [4,5].

3. IMAGING

The following structures and organs can be visualised with ultrasound: urinary bladder, urethra, pubic bone, vagina, rectum and uterus. It should be emphasised that there are differences according to the ultrasound probe used, its frequency and the angle of projection. Vaginal and rectal ultrasound represent a sagittal section showing the uterus, urinary bladder, urethra and pubic bone, whereas introital and perineal sonography allow a panoramic view of the pelvis (Figure 8).

4. PICTURE ORIENTATION

The recommendation for the picture orientation is to depict cranial parts above and ventral parts on the right side. This kind of picture orientation corresponds to the representation of transvaginal ultrasound pictures preferred in European countries [14] and to the recommendations of Merz [15], Bernaschek [16] and the ICS [17] [*Level of evidence: intermediate*].

5. MEASUREMENT

Ultrasonographic examination of the bladder neck and urethra can be performed with the patients lying, sitting or standing although the study is often carried out in a supine position with the legs slightly abducted. Examination in the sitting position requires dedicated ultrasound systems to guarantee the optimal position of the probe on the perineum [18].

Bladder neck position changed little in different patient positions [19] although its mobility has been considered to be maximal in the standing position [19, 20] [Level of evidence: intermediate]. Thickness of the rhabdosphincter can be measured in transverse sections. The volume of the urethral sphincter is calculated, in female patients, using a step sectioning technique in transverse sections. Submucosal vascular plexus is imaged on a sagittal midline section with introital sonography.

Currently the retrovesical angle b and the position of the internal urethral orifice are the most important quantitative parameters [***High Level Evidence***].

The retrovesical angle β is measured as follows: one side of the angle is formed by the urethral axis, the other side by at least one-third of the bladder base near the bladder neck.

For determination of the internal urethral orifice two methods were previously investigated and their reproducibility analysed [20 21]. Both relate to the pubic bone as a stable structure of the pelvis, which allows drawing an accurate reference line (central line of the symphysis).

Schaer et al (Figure 9) used a rectangular co-ordinate system where the x-axis is determined by the central

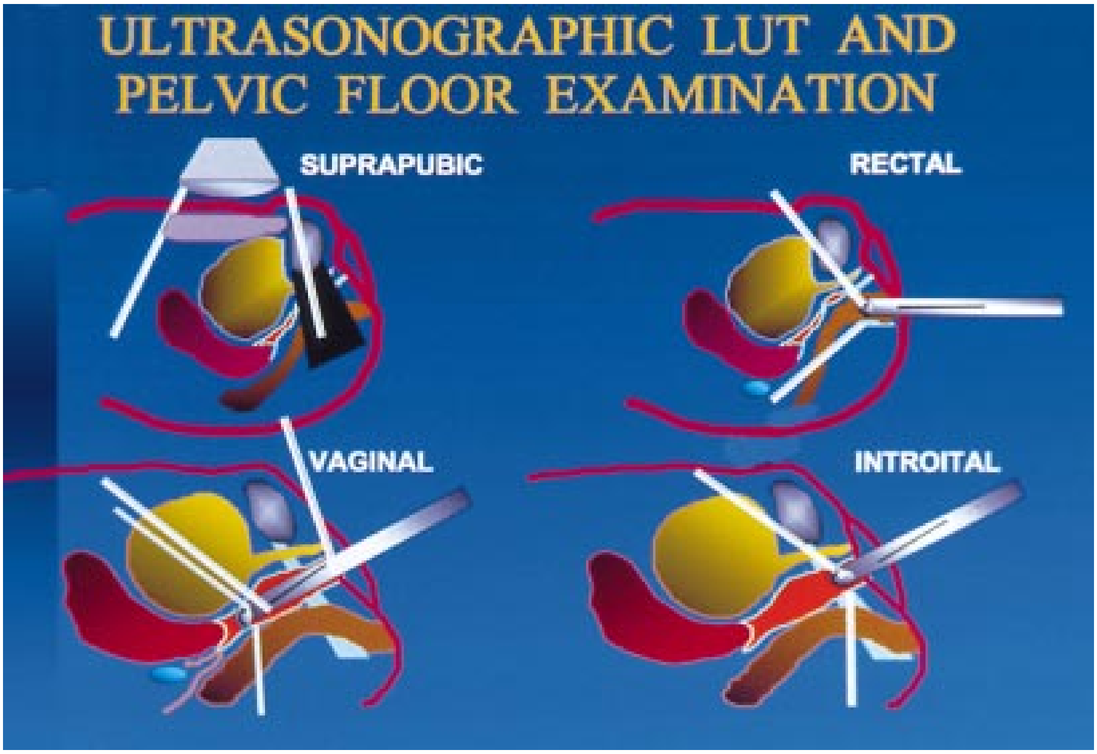


Figure 8 : Ultrasound of the lower urinary tract and pelvic floor

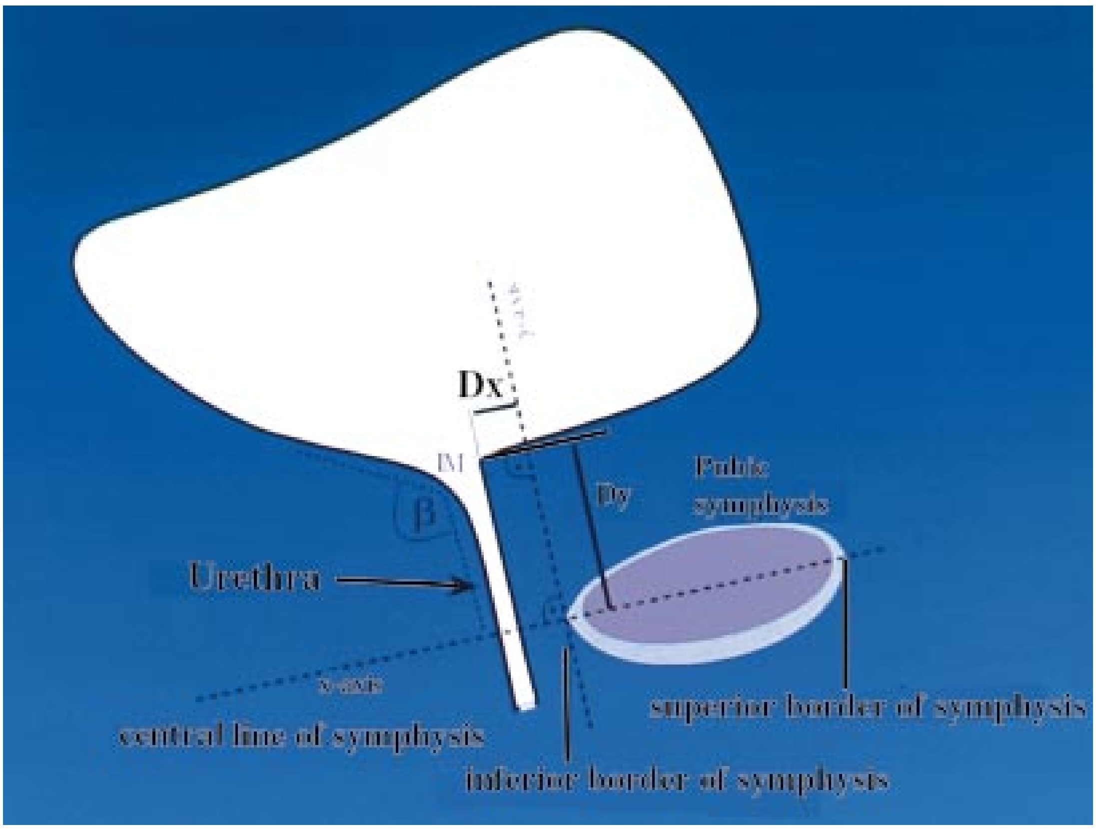


Figure 9 : Quantitative parameters of female lower urinary tract ultrasound

line of the symphysis. The y-axis is constructed perpendicular to the x-axis at the lower border of the symphysis. Dx is defined as the distance between the y-axis and the bladder neck, and Dy is defined as the distance between the x-axis and the bladder neck. For precise localisation of the bladder neck, the upper and ventral point of the urethral wall at the immediate transition into the bladder is used.

Creighton et al. measured bladder neck position with one distance and one angle. The distance is measured between the bladder neck and the inferior border of the symphysis and the angle between this distance line and the central line of the symphysis (pubourethral angle).

Qualitative parameters are bladder neck funneling (yes, no), position (high, low) and mobility (fixed, hypermobility) of the urethra and mobility of the bladder base (vertical, rotational or no descent).

6. Comparison between ultrasound and other imaging techniques

Each imaging technique has its own advantages and disadvantages (Table 2). Cystourethrography is based on projection pictures through the whole pelvis, it does not image any soft tissue except the bladder and urethra but offers several reference points. Ultrasound cuts a thin picture through the pelvis, it provides imaging of various pelvic organs and structures and provides a single reference point: the pubis. MRI produces a global view of the neuromuscular structures and organs of the pelvis which can be imaged through any plane. Ultrasound requires contact between the pelvic floor and the probe while other imaging techniques do not [1 - 3, 9, 22 - 24].

Table 2 : Advantages and disadvantages of ultrasound compared to other imaging techniques:

Advantages	Disadvantages
No irradiation	Inferior visualisation of bladder neck funneling
No catheter or wick	No representation of the entire bladder
No potentially allergenic contrast medium	No representation of pelvic muscle and adjacent structures
Availability	
Less invasive	
High acceptance (patients, physicians)	
Additional information on pelvic organs	
Therapy control	
Visual biofeedback (pelvic floor contraction)	
Less expensive	

7. Examination position

The patient's position has an influence on the measurement results. Bladder neck position at rest is relatively independent from patient position and the bladder neck to pubis distance was only slightly higher in sitting compared to supine patients (difference = 0.32 ± 0.12 cm) [25]. Examination in the sitting position resulted in bladder neck descent to a lower level compared to the supine position with an average increase of the rotation angle (β angle) by 16° [25]. If the evaluations are repeated in the same position using different imaging techniques the measured differences seem to be small and not of great importance [23, 24, 1, 2]. With the subject standing bladder neck funneling is found more frequently, and the descent of the bladder base is larger [9, 21, 26].

8. Bladder filling

Bladder volume has only slight influence on the bladder neck position and on the retrovesical angle b; with a greater bladder volume, bladder neck funneling is more often detected [25, 20, 27]. The evaluation should be performed with a bladder volume of 300 ml. Only standardised bladder volumes allow reliable comparisons of pre- and post-operative findings [***Level of evidence: high***].

9. Provocation tests

Coughing and the Valsalva manoeuvre are the most commonly used provocation tests to assess genuine stress incontinence. The results of both these tests differ as follows: during Valsalva the bladder neck lies lower and more dorsally and the angle b is larger [28, 19, 20]. Valsalva seems (physiologically) to be related to pelvic floor relaxation and coughing to contraction of the pelvic floor. Therefore, the Valsalva manoeuvre reveals descent better than coughing [29].

10. Variations caused by the ultrasound probe

Ultrasound requires body contact which differs from technique to technique. Endoluminal techniques lead to a bigger distortion of the urethrovesical anatomy than external techniques [9, 25]. The presence of the endocavitary probe can influence the bladder neck position and the angle β [21, 12, 11, 19, 30]. The evaluation should be performed with low pressure upon the visceral wall, just sufficient to obtain a good image [20].

11. Standardisation

Standardisation methodology and evaluation of ultrasound imaging of the bladder has been proposed by the German Association of Urogynecology and by the ICS [16, 17]. They recommended the following.

Picture orientation: cranial structures are to be shown above, caudal structures below and ventral structures on the right, dorsal structures on the left.

Imaging: to include urinary bladder, urethra, pubic bone, vagina, rectum, (uterus).

Measurement method: position of the internal urethral orifice should be related to the inferior border of the pubic bone (x-y co-ordinate system or pubourethral angle and distance) and retrovesical angle b.

Examination position: evaluation on the supine patient is preferable for patient comfort, bladder neck funnelling is more easily imaged in the sitting or standing position in patients with stress incontinence.

Bladder filling: 300 ml.

Provocation tests: imaging should be performed at rest and during Valsalva manoeuvre, pelvic floor contraction and coughing.

Variation caused by the ultrasound probe: beware of possible modification of bladder neck and urethral anatomy by endorectal or endovaginal ultrasound probes.

12. Role of the investigation

Ultrasound still remains an investigational technique although it is frequently used in the evaluation of female urinary incontinence and prolapse and allows functional and morphological documentation. It may not stand alone as a tool for diagnosing stress urinary incontinence because measuring bladder neck position and retrovesical angle β does not reliably predict urinary incontinence [19]. The dynamic process of bladder filling, emptying and other activities such as coughing, Valsalva and pelvic floor contraction can be illustrated helping to understand the association between anatomy and function.

Several studies have examined the reproducibility of sonographic examination of bladder neck position and no significant differences between the measurements performed by two investigators were found. A 95% CI of -4.88 to 6.29, -5.57 to 6.37, -2.93 to 5.08 was found, between 2 investigators, as regards the value of the α angle at rest, during squeezing and Valsalva respectively. No significant differences were observed in the x axis, y axis and β angle measured by two investigators [19, 24, 29, 33]

An extensive article from Bernstein [31] suggests that introital sonography provides adequate imaging of the pelvic floor; reduction of levator ani thickness with ageing was found both at rest as well as during exercise and a similar decrease of muscle mass was evident in incontinent women. Ultrasound imaging was able to show hypertrophy of pelvic floor muscles following pelvic floor training although no correlation was found with subjective and objective parameters of incontinence severity.

Pelvic floor muscle thickness has been measured by perineal ultrasonography in healthy and urinary incontinent women before and after training with 95% confidence interval of +/- 7-12%. In healthy women the median figures (and ranges) at rest, during contraction and increment during contraction were 9.8 mm (7.7-11.7), 11.2 mm (8.5-13.0) and 1.3 mm (0.2-2.0) respectively. The corresponding figures for incontinent women before training were 9.2 mm (6.7-11.3), 10.2 (7.0-12.7) and 1.1 mm (0.0-2.5) and after training 9.7 (7.8-11.7), 11.2 mm (9.2-13.2) an 1.5 mm (0.2-3.5) respectively [32].

New developments, such as, improved visualisation of funnelling by using ultrasound contrast medium [33] or depiction of structural defects with 3-D [4, 34, 35] (paravaginal defects) or intraurethral ultrasound [36] (sphincter defects) may lead to a movement of pelvic floor ultrasound from documentation of sagittal anatomy to a diagnostic tool of pelvic floor defects.

Further exploratory work is required to investigate the possible clinical benefit of ultrasound imaging in female urinary incontinence (Figures 10-17).

13. Conclusion

Lower urinary tract sonography is still regarded as an investigational technique for dynamic visualisation of urethral and bladder neck behaviour during Valsalva manoeuvre, coughing and pelvic floor contraction. Ultrasound imaging, especially with a perineal approach, can provide evidence as to urethral hypermobility and pelvic organ prolapse.

Standardisation of ultrasound technique is currently underway and is necessary to allow comparison of study protocols using ultrasound and to assure reliable and reproducible results. Evaluation of bladder neck and bladder base behaviour remains an indirect sign of pelvic floor function and integrity. Preliminary reports on new techniques, such as, intraurethral and 3-D ultrasound indicate that the future of ultrasound moves towards direct visualisation of defects, such as paravaginal or sphincteric defects.

Pelvic floor ultrasound is an investigational technique in rapid development. At present, its role in the evaluation of female urinary incontinence is not yet established. Intra-observer and inter-observer variability of ultrasound imaging of the bladder in the incontinent female patients has been tested and found to be on no statistical or clinical significance.

In conclusion, pelvic floor ultrasound does not provide a diagnosis of stress or urge incontinence, but it can be helpful in diagnosing urethral hypermobility and it can be a helpful technique to document pelvic organ prolapse (***Intermediate Level Evidence***).

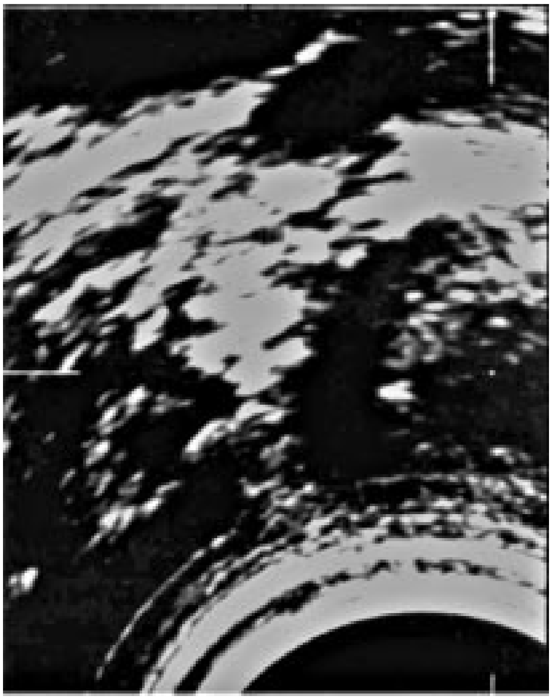


Figure 10 : Histology and ultrasound of the female urethra

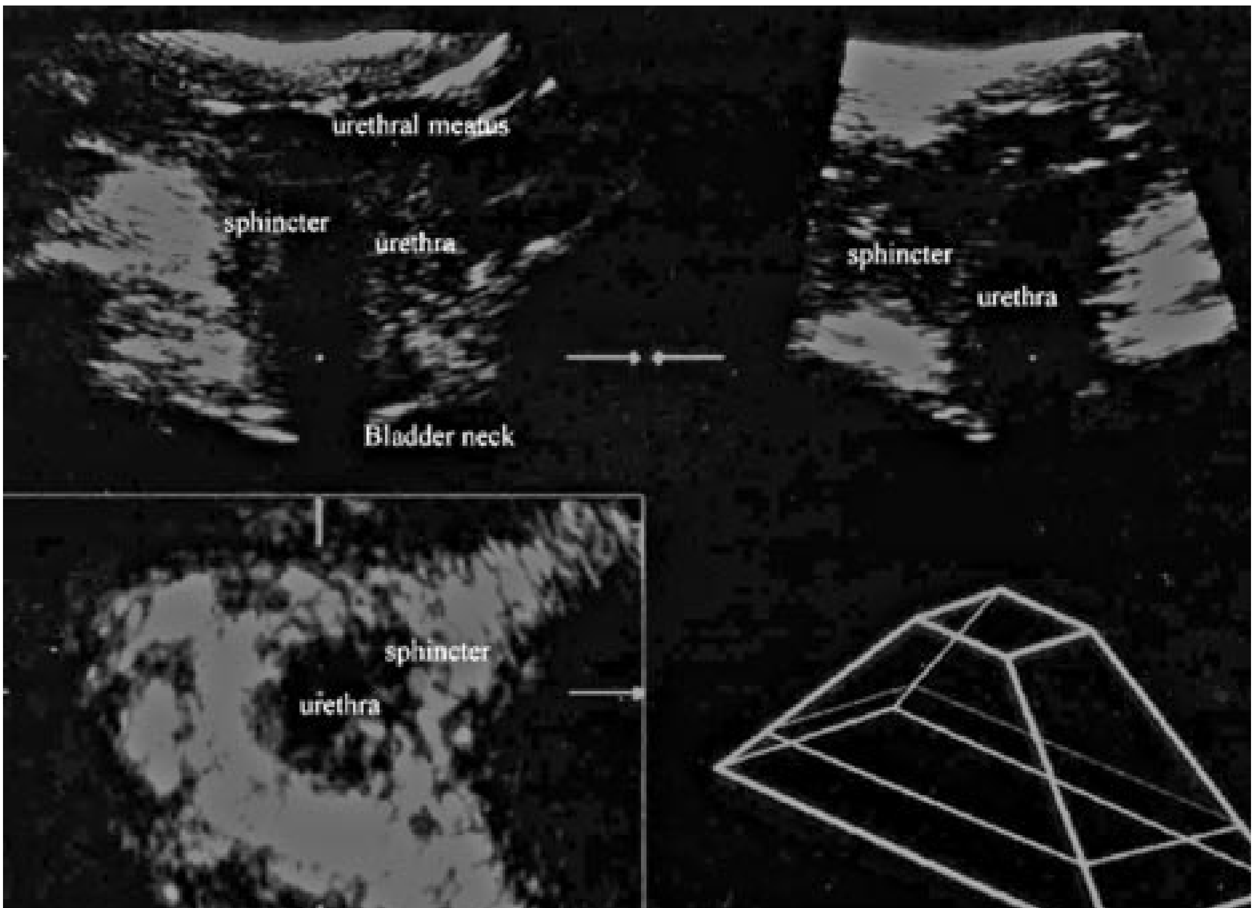


Figure 11 : 3d urethral sphincter scan

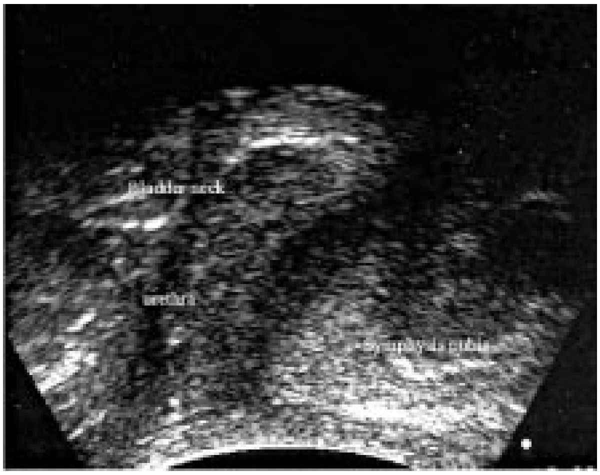


Figure 12 : Introital scan: well supported bladder neck

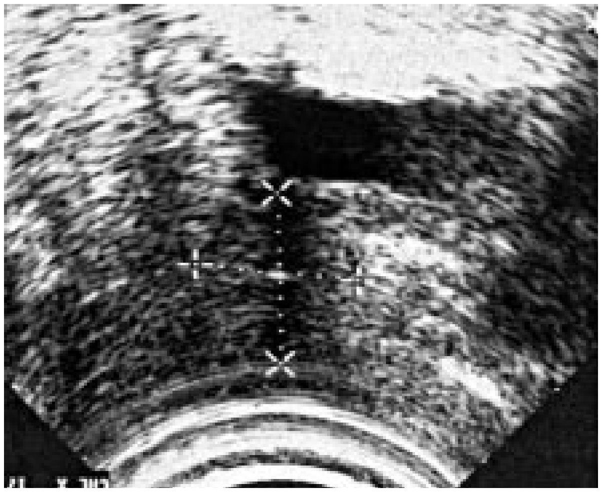


Figure 13 : Transperineal urethral sphincter at rest

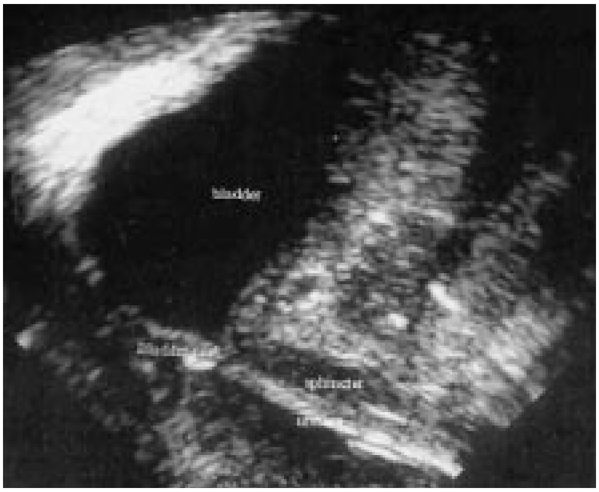


Figure 14 : Transrectal view of bladder neck and urethra

Figure 15 : Transperineal scan: bladder neck on strain

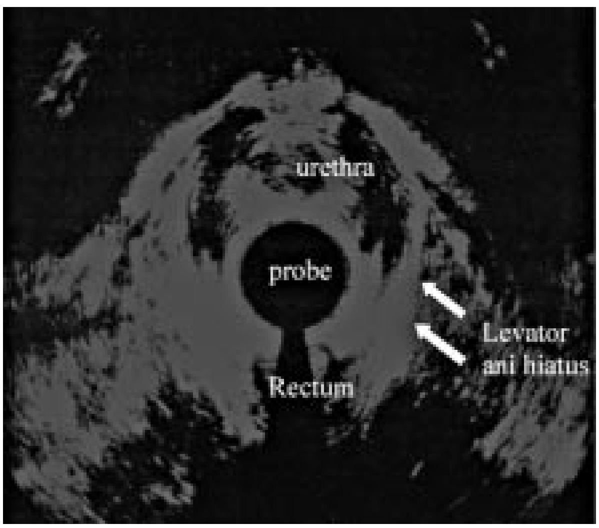


Figure 16 : Levator ani hiatus

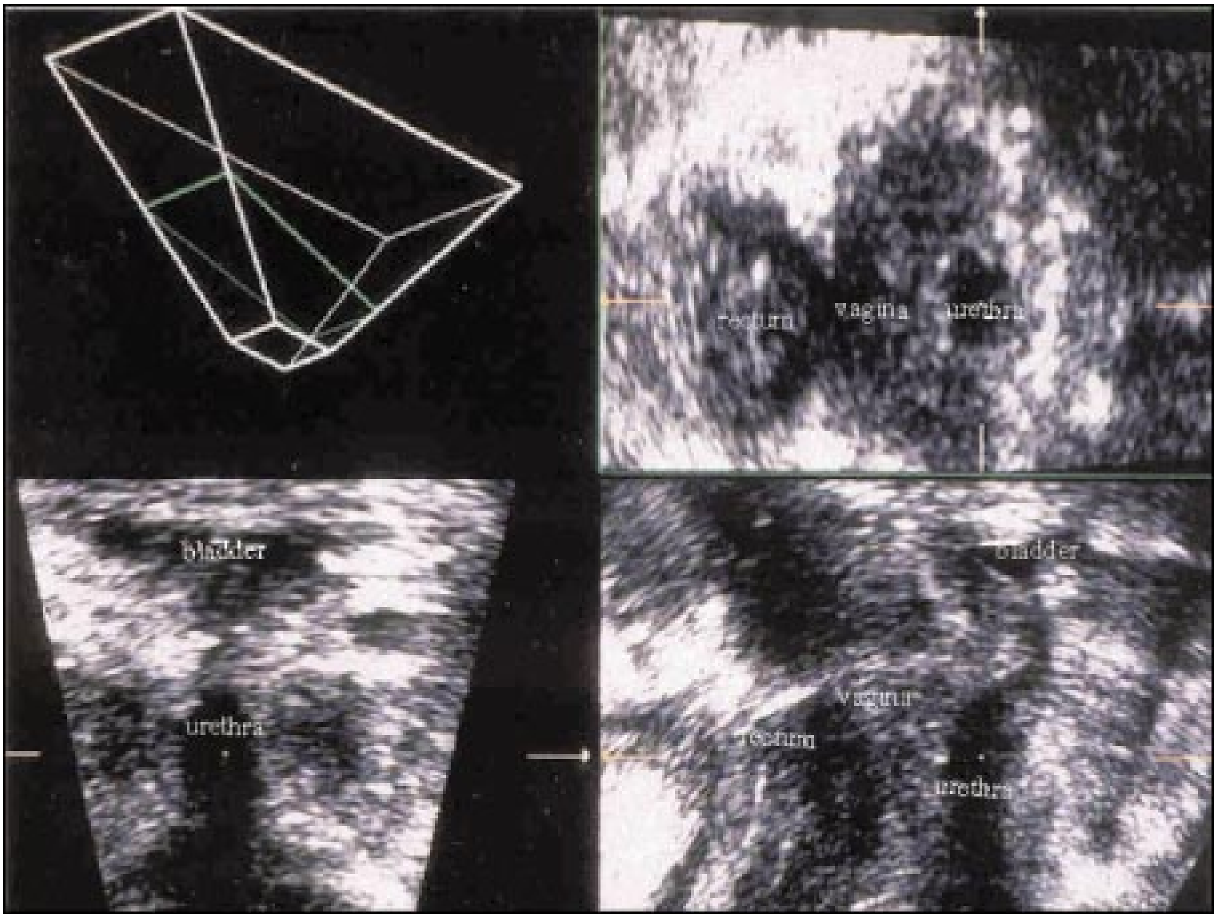


Figure 17 : Pelvic floor 3D scan

14. Recommendations

1. LUT and pelvic floor ultrasound ultrasound is NOT indicated in the evaluation of uncomplicated stress, urge or mixed female urinary incontinence (***Unanimous agreement***)

2. LUT and pelvic floor ultrasound should be considered an investigational imaging technique in the evaluation of female urinary incontinence and pelvic floor (***Unanimous agreement***)

15. Suggested research areas

1. Role of pelvic floor imaging in the evaluation of female urinary incontinence

2. Standardisation of US imaging in incontinence

Relation of ultrasound imaging to bladder neck function

3. Relation of ultrasound imaging to treatment outcome

4. New technologic developments

5. Need for proper training and full understanding of methodology

III. MRI OF PELVIC FLOOR

1. Background

Pelvic floor dysfunction encompasses a variety of fascial and anatomic defects that can affect the anterior wall, posterior wall, and apex of the vagina. Since cystocele, rectocele, uterine prolapse, enterocele, vault prolapse, and urinary incontinence tend to coexist, it is important to thoroughly evaluate all components of the pelvic floor. It has been shown that although patients might present with symptoms isolated to one pelvic floor compartment, the majority of these patients have concomitant defects in other compartments [1]. Since surgical failures have been attributed to the lack of a thorough preoperative evaluation of the female pelvis and to inadequate diagnosis and staging of pelvic floor dysfunction [2], accurate diagnosis of the coexisting abnormalities is essential in planning reconstructive and anti-incontinence procedures. In addition, up to 30% of female patients that present with stress urinary incontinence suffer from concomitant pelvic floor prolapse. Although most diagnoses of pelvic floor prolapse are made on detailed physical exam, various studies have alluded to the poor sensitivity and specificity of the pelvic exam in diagnosing various forms of pelvic floor prolapse [3 - 5].

Fluoroscopy has been used to evaluate the rectum and bladder and to aid in the diagnosis of cystocele and rectocele [3 - 4, 6]. Subsequently, pelvic ultrasonography was introduced as a less invasive alternative to fluoroscopic studies [7]. Recently, magnetic resonance imaging (MRI) has been used in the diagnostic evaluation of pelvic floor dysfunction. MRI provides anatomical detail of the pelvic floor including assessment of bladder neck and urethral mobility, rectocele, cystocele, enterocele and uterine prolapse, in a single non-invasive study which does not expose the patient to ionizing radiation [8 - 17]. MR imaging also provides a multiplanar thorough evaluation of the pelvic contents including the uterus, ovaries, ureters, kidneys, and levator muscles, as well as the urethra, that is unavailable by any other imaging modality [10, 12 - 16, 18, 19]. MRI provides useful information regarding ureteral obstruction, hydroneprosis, and uterine and ovarian pathology, which is essential in the management of women with pelvic floor disorders. In addition, at this time, MRI is the study of choice for the evaluation of urethral diverticuli (see related section).

2. Methodology

a) Conventional MRI

Advantages of MRI include lack of ionizing radiation, depiction of the soft tissues of the pelvic floor, and multiplanar imaging capability. Standard MRI consists of two dimensional image acquisition. Usually conventional T1 images and spin echo T2 weighted images are obtained. These static images provide good information on anatomy and pathological abnormalities but the long imaging time of conventional MRI has hampered its ability to evaluate pelvic organ prolapse and pelvic relaxation.The muscular anatomy of the pelvic floor, as well as the anatomy of the pelvic organs can be visualized with the use of a body coil. The use of an endovaginal coil provides superior information regarding the zonal anatomy of the urethra but the deformity of the normal anatomy by the coil itself should be considered. [20 - 21].

b) Ultra fast image acquisition and MR sequences

Very fast single-shot MR sequences for the evaluation of pelvic prolapse have been recently developed that allow excellent visualization of the pelvic floor in women [14, 15, 22 - 23]. These sequences allow a series of 1-second breath hold images to be obtained in two ways, either by obtaining a series of images covering the entire pelvis (static imaging) or repetitively in one plane while the patient is straining (dynamic imaging). The patients are placed in the supine position with legs slightly spread apart, and knees bent and supported by a pillow. There is no need for bowel preparation, premedication, instrumentation or contrast medium organ opacification. The MRI torso coil is centered at the symphysis pubis. Images are acquired in the sagittal plane using single-shot fast spin echo (SSFSE) or half Fourier acquisition, single shot turbo spin echo (HASTE) sequences. Single, mid sagittal views are obtained during 3 seconds of suspended respiration with the patient relaxed and during various degrees of progressive abdominal straining. The total MR room time is approximately 10-15 minutes.

Two sets of images are obtained. The first set consists of static sagittal and para-sagittal images covering the pelvis from left to right sidewall. These images provide information on pelvic anatomy, pathological abnormalities, and are used to select the mid-sagittal plane for the dynamic second set of images. This static sequence also allows for anatomic delineation of the pelvic sidewalls and muscular and fascial components of the pelvic floor [14, 15, 22 - 23] (Figure 18) The urogenital diaphragm and the levator ani musculature, as well as the anal sphincter anatomy, are also clearly demonstrated [24 - 25].

The static set consists of 17-20 sequential images independently acquired in a total of about 18 seconds. Static images can be acquired with a SSFSE pulse sequence using 128 x 256 matrix with repetition time (TR) of 4000 ms, echo time (TE) of 22.5 ms, 5 mm slice thickness and field of view (FOV) of 28 cm [15] Other similar sequences have been described.

The second set of images consists of relaxed and straining mid-sagittal images used to assess the degree of pelvic floor relaxation and organ prolapse (Figure 19 a,b). One series [15, 23] describes the SSFSE parameters as 128 x 256 matrix, TR = 4000ms, TE = 90 ms, FOV = 28 cm and 5 mm slice thickness. Variations in these parameters have been described and thus the image acquisition sequences have not been standardized. Images can then be looped for viewing on a digital station as a cine stack.

This technology gives us not only the ability to look at the dynamic changes of the pelvic supporting structures, it also provides information on pelvic floor relaxation, organ prolapse, and information on the anatomical changes produced during voluntary pelvic floor contraction. Imaging studies and surgical experience have taught us that incontinence is not an isolated event but a symptom in the spectrum of pelvic floor relaxation. Christensen et al. [26] evaluated the dynamic relationship between the bladder and surrounding organs by studying the effect of voluntary pelvic floor contrac-

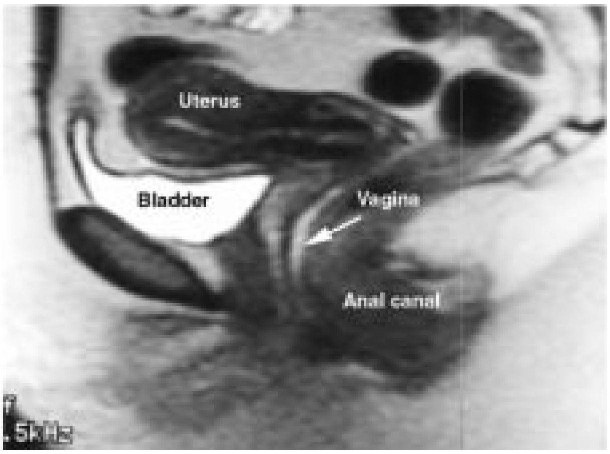


Figure 18 : Female pelvic floor MRI – sagittal view

Figure 19 a : Pelvic floor MRI: Mid sagittal image - relaxed

Figure 19 b : Pelvic floor MRI: midsagittal image on straining

tion on the abdominal structures. The authors quantitatively demonstrated that the displacement produced by contracting the pelvic musculature is larger in younger than older women suggesting changes due to aging. Mostwin et al. 27 found that incontinent women had significant pelvic floor displacement when compared to asymptomatic subjects.

c) Three dimensional MRI

Three dimensional (3-D) MRI provides great detail of the bony and muscular pelvic structures (Figure 20). In this technique, static or dynamic images are reconstructed using consecutive planes in the axial, sagittal and coronal dimensions. Anatomic variations of the insertion and pathway of the pubococcygeus and iliococcygeus muscles can be easily seen. Fielding et al. studied nulliparous continent female volunteers and found that the muscle morphology, signal intensity and volume are relatively uniform 28 They described an average volume of the levator ani of 46.6 cc, width of the levator hiatus of 41.7 mm and an average posterior urethovesical angle of 143.5°. A larger range of motion of the pelvic floor is seen in younger women as compared to older women. We have also learned that in multiparous and older women the width of the levator hiatus is enlarged. This is due to the central separation of the levator musculature allowing decensus of the pelvic floor as well as the pelvic organs. Since these structures play a role on urethral support, understanding the normal anatomy as well as changes seen on the levators and pelvic floor musculature will hopefully shed light on the etiology and possible treatment of urinary incontinence. One disadvantage of 3-D MRI its that at this time it takes a relative long time to obtain the three dimensional reconstructions.

3. Standardization of anatomy

a) Normal pelvic floor support

Static, dynamic and three-dimensional MRI studies of normal subjects have enhanced our understanding of normal pelvic anatomy 28 - 30. The use of MRI to analyze the pelvic floor musculature has also contributed greatly to our understanding of pelvic floor dysfunction 19, 21, 31. MR imaging has been used to study the normal female pelvic anatomy, as well as the anatomy of the aging female and the symptomatic patient. It has been shown that in the supine position the female pelvic floor is dome shaped at rest 31 - 32. During voluntary pelvic floor contractions the levator musculature straightens and becomes more horizontal. With bearing down the muscle descends, becomes basin-shaped, and the width of the genital hiatus widens. One limitation of MRI in the evaluation of the female pelvis is that the

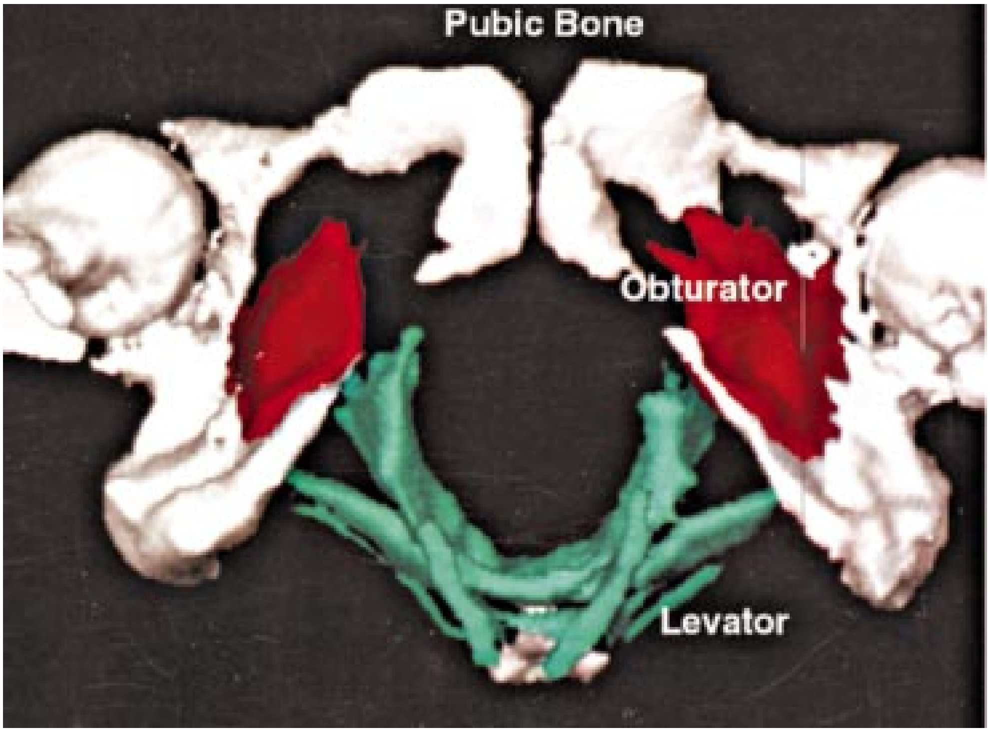


Figure 20 : 3D MRI of pelvic floor : 3D reconstruction of levator ani anatomy

studies are usually done with the patients supine. Upright dynamic MRI exists mostly as a research tool and is not widely available. Recently, Bø et al [33] evaluated the changes seen with pelvic floor contraction in continent and incontinent women using MRI in an upright sitting position. Although there was no statistical difference between the two groups, the authors demonstrated an inward movement with pelvic floor contraction (average 10.8 mm) and an outward movement with straining (average 19.1 mm). This was also reflected in the bladder neck. Interestingly, the coccyx appeared to move in the cranial direction with contraction and caudally with straining.

Another major advantage of MRI has been its ability to show the zonal anatomy of the urethra as well as the components of the intrinsic sphincteric unit. Figure 21 shows a coronal view of the urethra on a static MRI obtained with a vaginal coil. The anatomy of the urethra is clearly demonstrated. The lumen, spongy tissue and fibromuscular envelope are easily seen and correspond to the structures seen in urethral hislologic studies. A sagittal view of the urethral wall is seen in figure 22.

b) Anatomy after vaginal delivery

There are changes seen in the levator ani and pelvic floor musculature immediately after delivery which appear to change over time. Tunn et al evaluated patients on postpartum day 1 and compared the MRI images to those obtained at 1, 2, and 6 weeks and 6 months after delivery [25]. The authors evaluated levator muscle signal intensity, muscle topography, muscle thickness and pelvic floor descent. There was increased muscle signal intensity on T_2 weighted images at 1 day postpartum but the signal intensity approached normal by 6 months. The area of the urogenital and levator hiatus decreased significantly by 2 weeks postpartum. There was no statistically significant difference seen in muscle thickness over time.

c) Anatomy of urethra and bladder neck hypermobility

Saggital images obtained with the patient at rest usually show the urethra to be vertical in orientation [2a]. In patients with urethral hypermobility, with increased abdominal pressure, the proximal urethra moves inferiorly and the axis of the urethra becomes horizontal (Figure 23) [34]. In normal patients the urethral angle is usually greater than 30^o and the urethrovesical angle greater than 115^o . Tunn et al. [24] evaluated women with stress incontinence and compared them to controls. They found higher intensity of the levator musculature and loss of the hammock-like configuration of the anterior vaginal wall in patients with incontinence. A point of concern is that MRI is performed with the patient supine and that the lack of gravitational force might affect the anatomy seen in these images. This appears to be only a theoretical problem when evaluating patients with urethral hypermobility since both the descent of the bladder neck and the posterior urethrovesical angle do not seem to be affected by the MRI being performed in the sitting versus supine position [35].

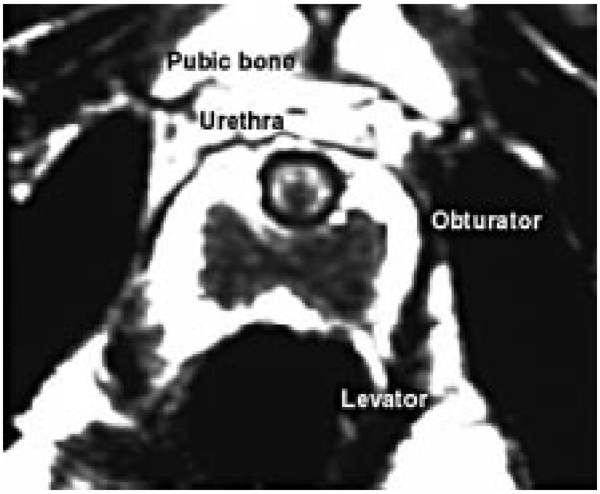


Figure 21 : MRI by vaginal coil Zonal anatomy of the urethra

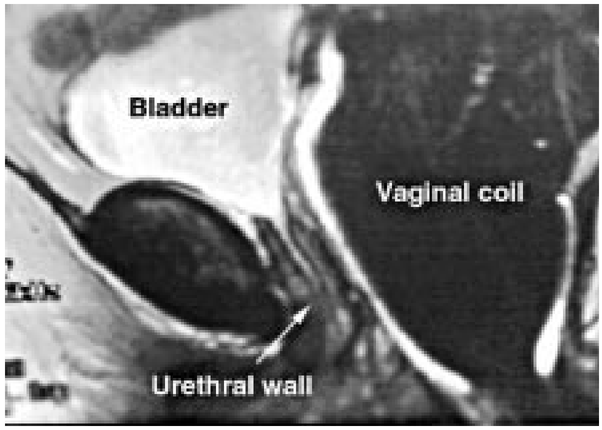


Figure 22 : MRI by vaginal coil Sagittal view

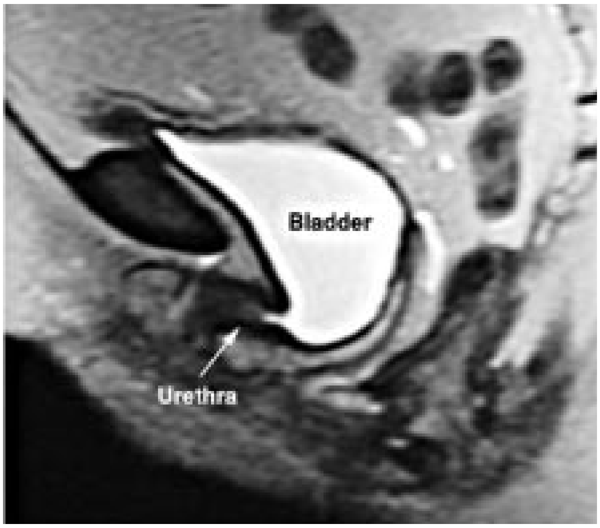


Figure 23 : Ultrafast MRI of pelvic floor during Valsalva

d) Anatomy of organ prolapse

Pelvic floor relaxation is a generalized condition involving all compartments of the pelvic floor. We can not evaluate incontinence in isolation since it is likely a result of changes in the anatomy and support of the female pelvis and is just one manifestation of pelvic floor relaxation and descent. The diagnosis of all components of pelvic prolapse is essential in surgical planning as well as in preventing surgical failures, recurrent prolapse and re-operations. Vaginal crowding due to the competition for space of the multiple organs descending into the vagina, makes the diagnosis of pelvic dysfunction difficult by physical exam alone.

Since pelvic floor dysfunction is usually generalized, the various pelvic floor compartments are best imaged simultaneously. Goose et al. evaluated the use of MRI in organ prolapse and compared the findings to physical exam and surgical finding 15. Pannu et al, presented a review of the anatomic changes seen with multiple forms of pelvic organ prolapse, including urethral descent and hypermobility 34. These studies have helped clarify the muscular and anatomic changes responsible for descent.

e) Anatomy after surgery

Various studies have looked at the anatomic changes seen after surgical procedures in order to better understand how surgical therapies affect pelvic support and structures. Lineman et al. 36 evaluated women after abdominal sacrocolpopexy. The authors found that functional cine MRI identified the exact sacral fixation points after the procedure and easily identified the axis of the vagina and the exact position of the synthetic material used for the repairs. Goodrich et al used MRI to provide a dynamic analysis and evaluation of patients before and after surgical repair to evaluate structures involved in pelvic support 37. Similar studies, will be needed in order to better evaluate the structures important for pelvic support, continence as well as the effects of surgical interventions.

f) Grading of Pelvic Floor Relaxation

A number of studies have described reference values for grading of organ prolapse 14 - 15, 17. In order to evaluate descensus, certain anatomic landmarks are used. The pubococcygeal line (PCL) marks the distance from the pubis to the coccyx and serves as a fixed anatomical reference). In the nomenclature used by Comiter et al. 14, Gousse et al. 15, and others 23, the width of the levator hiatus is measured as the distance from the pubis to the pubococcygeus muscle (H-line). The hiatus is formed by the puborectalis muscle and encompasses urethra, vagina, and rectum. The M-line depicts the relaxation of the muscular pelvic floor by measuring the descent of the levator plate from the

Table 3 : Grading of hiatal enlargement, pelvic organ prolapse and pelvic floor descent using MRI.

Grade	Hiatal Enlargement	Pelvic Organ Prolapse	Pelvic Floor Descent
0	Less than 6 cm	Organ above H-line	0-2 cm
1	6-8 cm	0-2 cm below H-line	2-4 cm
2	8-10 cm	2-4 cm below H-line	4-6 cm
3	10 cm or more	4 cm or more below H-line	6 cm or more

pubococcygeal line. Using these three simple measurements, an MRI classification for degree of organ has been described 14,35. In the normal population, during straining, the hiatus (H-line) is less than 6 cm long, and does not descend (M-line) more that 2 cm below the PCL line. The upper urethra, urethrovesical junction, bladder, upper vagina, uterus, small bowel, sigmoid colon, mesenteric fat and rectum are all above the H-line. A combination of hiatal enlargement and pelvic floor descent constitutes relaxation. As the pelvic floor descends so do the organs above it. The grading system for prolapse of any pelvic organ is based on 2 cm. increments below the H-line. By determining the degree of visceral prolapse beyond the H-line, the degree of rectocele, enterocele, cystocele, and uterine descent can be graded in a 0 to 3 scale as follows: 0 = none, 1= minimal, 2 = moderate, and 3 = severe (Table 3). Other similar systems have been described (17) and therefore there is a need for standardisation of nomenclature and grading of organ prolapse using MRI.

4. Indications

The advantages of MRI include: no need for urethral catheterization, no exposure to ionizing radiation, detailed anatomical views of the three pelvic floor compartments at rest and maximal pelvic strain, direct visualization of pelvic organs for evaluation of concomitant pathology, determination of urethral hypermobility, and evaluation of ureteral obstruction and post void residual 9 - 10 13 - 15 38 Its main disadvantage at this time is that the study is performed in the supine position and, therefore, the effects of gravity have not been clearly evaluated. In addition, organ space competition in the vagina can also interfere with accurate interpretation of coexisting organ prolapse.

a) Incontinence

MRI provides information on the supporting musculature of the urethra, on the sphincteric unit, on hypermobility of the urethra, presence or absence of stress urinary incontinence and on other concomitant defects of the pelvic floor. Although urethral hypermobily and stress urinary incontinence can be evaluated with MRI, its role in the evaluation of incontinence remains one of research tool and of understanding the multiple factors affecting the continence mechanism in women. On the other hand, at this point its clinical applications for the evaluation of incontinence appear limited. A theoretical application that has been postulated is using MRI to help select patients with intact pelvic floor muscular function that could be candidates for pelvic floor exercises and biofeedback. To date no MRI series has identified a significant subgroup of patients with obvious inability to recruit the pelvic muscles and therefore the use of MRI to choose a particular therapeutic approach is limited at this time. As our understanding of the supporting structures and how their changes affect the development of incontinence increases, there might be a future role of MRI in evaluating incontinent women and determining which particular anatomic support needs to be addressed and thus directing specific surgeries for specific defects. At this time this remains only as a theoretical consideration.

b) Pelvic floor relaxation and organ prolapse

- *Enterocele*

An enterocele is often missed on physical examination when it is accompanied by other significant prolapse 7 In addition, physical examination often cannot reliably distinguish an enterocele from a high rectocele. In the past, defecography was the only available study to aid in the diagnosis of enteroceles. Enteroceles were usually only appreciated after repeated straining after evacuation and usually required opacification of the vagina in order to demonstrate the insinuation of small bowel loops between the rectum and vagina 39. MRI has proven to be a much simpler and less invasive technique for the evaluation of enteroceles. Gousse et al. compared physical exam, intraoperative findings and MR images in women with and without prolapse 15. The investigators found that when compared to intraoperative findings, MRI had a sensitivity of 87%, specificity of 80%, and positive predictive value of 91%. MRI was significantly superior in detecting enteroceles when compared to physical examinations. The images are obtained with the patient supine in the relaxed and straining state (Figure 24 a,b). Neither instrumentation nor invasive procedures are needed. Similarly, Lienemann et al., using MRI with opacification of organs, showed that MRI had a much higher sensitivity for detection of enteroceles when compared to physical exam and dynamic cystoproctography 40

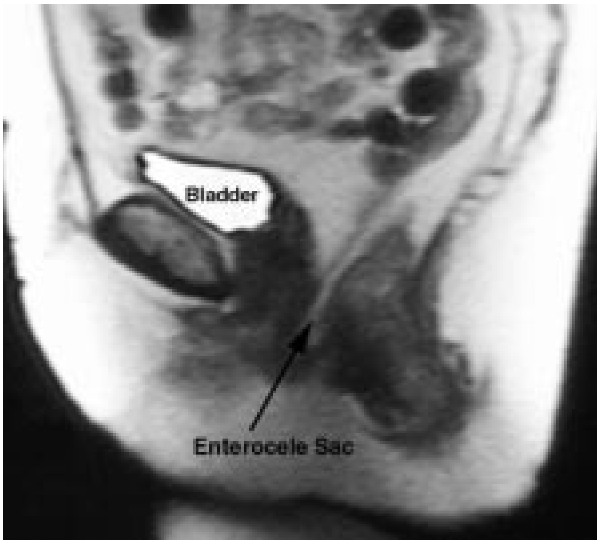


Figure 24 a : Pelvic floor MRI: enterocele a) At rest

Figure 24 b : Pelvic floor MRI: enterocele b) during Valsalva

- *CYSTOCELE*

As with other forms of prolapse, high-grade cystoceles usually do not occur in isolation, and represent a spectrum of pelvic floor dysfunction [1], [3], [14] When a large vaginal mass is present it is frequently difficult to differentiate a high-grade cystocele, from an enterocele, vaginal vault prolapse or high rectocele by physical examination alone [3 - 5]. In addition repair of only the cystocele without attention to the rest of the pelvic floor has been shown to predispose the patient not only to increased incidence of urinary incontinence, but also to an increase incidence of enterocele, rectocele, and/or uterine prolapse postoperatively [15]. Figures 25 a, b show an MRI of two patients with grade 2 and 3 cystocele, respectively. When compared to intraoperative findings, MRI has a sensitivity of 100%, specificity of 83%, and positive predictive value of 97% when evaluating for cystocele [15]. In addition, urethral hypermobility and post-void urine residual can be documented, as well as evaluation of ureteral obstruction and other pelvic abnormalities. Gousse et al. found that MRI was able to diagnose other type of pelvic pathology besides prolapse in 55 of 100 patients studied, including 3 with bilateral hydroureteronephrosis [15].

- *RECTOCELE*

Rectoceles are present in up to 80% of asymptomatic patients with pelvic floor dysfunction [13]. Although the diagnosis is usually made by physical exam, the reported sensitivity of pelvic examination for diagnosis of rectocele ranges from 31% to 80% [3 - 4] [6] [41 - 42]. This is usually secondary to organ competition for space in the vagina when accompanied by other significant prolapse [7]. In addition, it is often difficult to reliably distinguish an enterocele from a high rectocele. Figure 11 shows a rectocele diagnosed by dynamic MRI. A rectocele is easily seen when filled with gas, fluid, or gel. Although highly specific, when no rectal or vaginal opacification is used, MRI can miss up to 24% or rectoceles [15]. When rectal opacification is used during MRI, a correct diagnosis of rectocele can made in 100% of patients studied when compared to intraoperative findings [18]. It therefore appears that in order to increase MRI's ability to diagnose rectocele, rectal opacification is necessary. This is usually accomplished by introducing sonographic transmission gel or gadolinium into the rectum prior to MRI scanning.

- *UTERINE PROLAPSE*

The size of the uterus and the presence of concomitant uterine or ovarian pathology determine if a vaginal or abdominal hysterectomy is performed at the time of the prolapse repair. Because of the need to rule out malignancy as well as the fact that grade four uterine prolapse has been associated with insidious progressive ureteral obstruction, MRI is an excellent modality to evaluate uterine prolapse (Figure 26). It evaluates not only uterine size, position, orientation (retroversion) and pathology (fibroids, tumors, nabothian cysts, etc.), but also ovarian pathology (cyst of mass) which is essential information in determining if a vaginal of abdominal hysterectomy is indicated. In addition, MRI provides information on the presence or absence of cystocele, rectocele, urethral hypermobility and urethral diverticula, and evaluates for ureteral obstruction [9 - 10] [13 - 15], [38]. Gousse et al report a sensitivity of 83%, a specificity of 100% and a positive predictive value of 100% when comparing dynamic MR imaging to intrao-

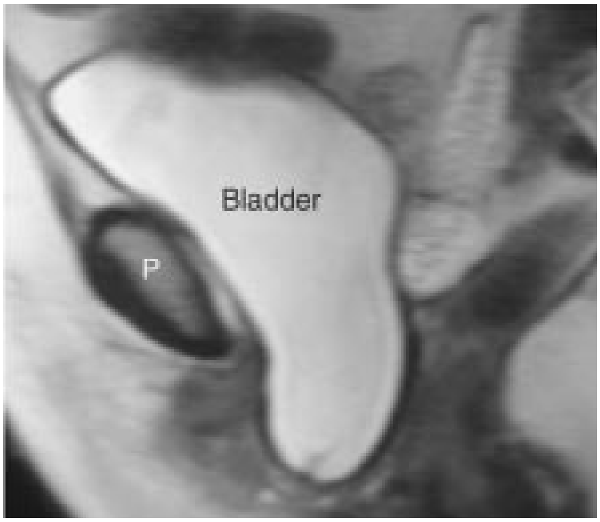


Figure 25 a : Pelvic floor MRI: grade 2 cystocele

Figure 25 b : Pelvic floor MRI: grade 3 cystocele

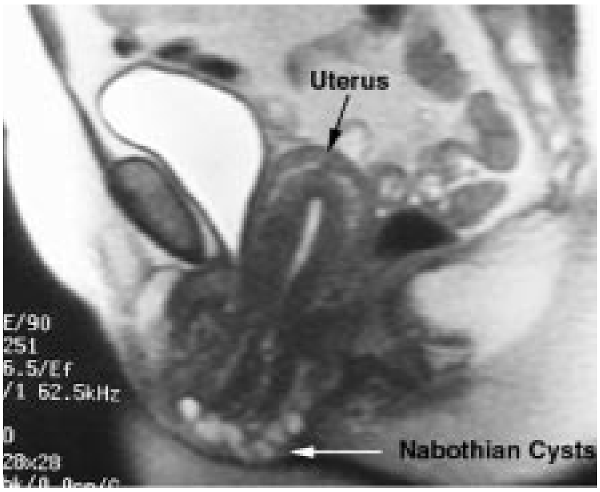


Figure 26 : Pelvic floor MRI: hysterocele

perative findings. These numbers were similar when compared to physical examination alone [15]. More importantly, MRI was able to clearly define the other compartments of the pelvic floor and diagnose uterine and/or ovarian in 30 of 100 patients evaluated [15].

5. Comparison between CT, MRI, ultrasonography, VCUG, and fluoroscopic cystocolpoproctography.

In the evaluation of incontinence and simple low-grade cystoceles, the studies of choice are the voiding cystourethrogram (VCUG) and urodynamics. VCUG is useful in determining the severity of cystocele, evaluating for urethral hypermobility and stress urinary incontinence, and documenting post void residual [6]. In addition to the above information, the evaluation of high-grade cystoceles should provide information on concomitant pelvic floor prolapse and presence or absence of urinary retention and ureteral obstruction [9 - 10, 13 - 15, 38]. Gufler et al. compared chain cystourethrography with dynamic MRI [38]. The authors found that with pelvic straining the measurements of bladder neck descent, angle of the urethra and the posterior urethrovesical angle, were not significantly different. This was not the case with perineal contraction, where the difference between the measurements was more marked. In the diagnosis of cystocele, MRI had a high degree of correlation to lateral cystourethrography with a Spearman correlation coefficient of 0.95 [38].

In urinary incontinence research, CT scanning has provided important information such as the effect of straining on the posterior component of the levator ani muscle. At this point the detail of the soft tissues obtain by MRI is superior to that of CT scanning, and therefore it has become the preferred research tool in studying the pelvic floor and its contents.

Until recently, dynamic contrast roentography and multiphasic fluoroscopic cystocolpoproctography were considered the best radiologic studies for detecting organ prolapse. These studies rely on the opacification with contrast material of the bladder, vagina, small bowel, and rectum with all organs opacified together or in phases with each organ opacified individually prior to each straining phase [4, 41, 43 - 44]. These studies fail to detect up to 20 percent of all enteroceles [38, 44 - 46]. Therefore, MRI has proven to be a much simpler and less invasive technique for the evaluation of enteroceles. In addition, MRI is able to differentiate the enteroceles according to their contents (small bowel, large bowel, rectosigmoidocele or mesenteric fat). MRI is also an excellent study to differentiate high rectoceles form enteroceles, thus allowing adequate surgical planning and safer planes of dissection [14, 15, 18, 40]. Although a recent study found that multiphasic MRI with opacification of organs and multiphasic fluoroscopic cystocolpoproctography had similar detection rates for enterocele [44], excellent images can be obtained from dynamic MRI without giving the patient oral contrast for opacification of the small bowel or giving rectal contrast. Thus the minimal added information obtained by contrast administration does not seem to warrant the invasiveness of organ opacification at this time [15, 39, 45].

In the evaluation of rectoceles, evacuation proctography has been used to diagnose enterocele, retoceles, perineal descent and rectal intussusception [36]. Dynamic contrast roentography or fluoroscopic cystocolpoproctography have also been used [4, 41 - 42, 43 - 44] to diagnosed rectoceles. The disadvantages of these techniques are the inability to visualize the soft tissue planes comprising the pelvic floor, their invasiveness, and their use of significant levels of ionizing radiation. Without the use of rectal opacification, MRI appears to be a poor choice for the evaluation of rectoceles missing up to 25% of such defects. When rectal opacification is used during MRI, Tunn et al. showed that a correct diagnosis of rectocele can made in 100% of patients studied when compared to intraoperative findings [18]. Other investigators have also shown that triphasic dynamic MRI and triphasic fluoroscopic cystocolpoproctography have similar detection rates for retocele [44]. Recently, upright dynamic MR defecating proctography has been reported [47]. Although these studies might prove to be more sensitive in detecting anorectal anomalies, their utility seems to be more pronounced in patients with disorders of defecation including anismus, intussusception, and others, and may be too invasive to justify their routine use in the evaluation of rectocele.

In the past pelvic ultrasound has been used for the evaluation of the pelvic organs specially prior to hysterectomy for uterine prolapse. MRI provides excellent information on uterine masses such as fibroids or carcinoma, as well as ovarian cystic (simple or complex) and solid masses. Hydrosalpynx and other abnormalities of the fallopian tubes as well as Nabothian cysts of the cervix and Bartholin's gland cysts are also easily seen. MRI can also be used in the evaluation of endometriosis since size and extent of edometriomas as well as pelvic organ involvement can be easily evaluated.

5. Conclusions

The use of new MR rapid sequences have allowed for the fast, detailed, and reproducible evaluation of the female pelvis including normal anatomy, pelvic floor relaxation and pelvic organ prolapse. Although MRI can provide information regarding normal anatomy, incontinence, cystocele, rectocele, uterine prolapse, enterocele and presence or absence of pelvic pathology, the main clinical contribution at this time has been in the evaluation of enterocele (***High Level Evidence***). Even though, MRI appears to provide clinically useful information related to incontinence and prolapse in a single study that does not expose patients to ionizing radiation, further studies are needed before the widespread use of MRI can be recommended (***Intermediate Level Evidence***).

6. Recommendations

1. MRI is NOT indicated in the evaluation of patients with urinary incontinence or pelvic prolapse. (**Unanimous agreement**)
2. MRI should be considered an investigational imaging technique in the evaluation of female urinary incontinence and pelvic floor dysfunction (**Unanimous agreement**).

7. Suggested research areas

1. Additional studies comparing MRI of healthy volunteers and patients with urinary incontinence and prolapse are needed to better evaluate the anatomic changes involved in urinary incontinence and pelvic floor prolapse.
2. Serial MRI of healthy volunteers are needed to better understand the effects of aging in the support structures of the pelvis and the association of these changes to the development of urinary incontinence and/or pelvic prolapse.
3. Additional studies evaluating patients before and after surgical correction and comparing anatomic changes of surgery to clinical outcomes are needed to better understand the effects of surgical intervention in the management of women with incontinence and/or prolapse.
4. Serial MRI in pre and postmenopausal women can help evaluate the influence of hormones in the pelvic support structures and the intrinsic structure of the urethra.
5. Studies of MRI with endoluminal coils might help understand the structural relationship between the spongy tissue and the fibromuscular envelope of the female urethra and evaluate their role in the intrinsic function of the urethra.

B-II. LOWER URINARY TRACT IMAGING IN POST-PROSTATECTOMY INCONTINENCE

Video-urodynamics is at present the gold standard for evaluating post-prostatectomy urinary incontinence [1 - 4]. The retrograde urethrogram and cystourethrography (as well as endoscopy) can have a role in identifying the presence of anastomotic strictures and possibly in defining the pathophysiology of urinary incontinence [5]. Presti et al [6], comparing 24 incontinent patients to 13 continent patients after radical prostatectomy, showed that the appearance of the bladder outlet on voiding cystourethrography was correlated with urodynamic parameters and the presence or absence of incontinence. Tubularisation above the level of the external sphincter was present in continent but absent in incontinent patients. The anatomical configuration of the reconstructed bladder outlet can influence, together with the integrity of the distal urethral sphincteric mechanism and the functional detrusor behaviour, the degree of urinary continence after radical prostatectomy.

I. RECOMMENDATIONS

Radiologic evaluation of the lower urinary tract by means of the retrograde urethrogram and voiding cystourethrography (or preferably video-urodynamics) is recommended in cases of persistent post-prostatectomy urinary incontinence. (**Low Level Evidence- Unanimous agreement**)

II. SUGGESTED RESEARCH AREA

Correlation between the morphologic appearance of the bladder outlet, functional parameters and clinical status (incontinence or continence) post-prostatectomy.

B-III. LOWER URINARY TRACT IMAGING IN NEUROGENIC INCONTINENCE

Ultrasound and cystourethrography are important tests of the lower urinary tract in patients with neurogenic dysfunction and urinary incontinence. They can provide information regarding the anatomy of the bladder and urethra, reflux, presence of diverticula, bladder wall thickness, presence of stones, and a reasonable assessment of residual urine. LUT imaging by ultrasound or cystourethrography can be performed as a separate test, but it is better performed at the time of urodynamic study (video-urodynamics) [1].

The use of ice-cooled contrast medium (iced cystourethrography) [2] can be useful in some suprasacral neurogenic patients in order to elicitate detrusor reflex and voiding.

Severe bladder trabeculation with diverticula and pseudodiverticula, reflux, wide bladder neck and proximal urethra, and narrowing at the level of the membranous urethra can suggest, mainly in children, the presence of neurogenic dysfunction of the lower urinary tract (occult spinal dysraphism, non-neurogenic neurogenic bladder) even in the absence of neurogenic symptoms and signs [3 - 5]. In these cases imaging abnormalities indicate the need for urodynamic evaluation, electrophysiological tests and central nervous system imaging.

I. RECOMMENDATIONS

1. Imaging of the lower urinary tract (preferably by cystourethrography) is recommended in the evaluation of evident or suspect neurogenic urinary incontinence. (***Intermediate Level Evidence- Unanimous agreement***)
2. Imaging would be preferably performed simultaneously with urodynamic evaluation (videourodynamics). However, when videourodynamics can not be performed, cystourethrography should be performed as a separate test (***Unanimous agreement***).

II. SUGGESTED RESEARCH AREA

Correlation between LUT, morphology and functional parameters.

B-IV. LOWER URINARY TRACT IMAGING: SPECIAL ISSUES

I. RESIDUAL URINE EVALUATION

Residual urine is defined as the volume of fluid remaining in the bladder immediately following the completion of micturition [1] (ICS definition).

The measurement of postvoid residual urine (PVR) can be performed by invasive and noninvasive means. Invasive means are: in-and-out catheterisation and endoscopy. Noninvasive means are transabdominal ultrasonography and radioisotope studies.

In-and-out catheterization is indicated as the gold standard for the measurement of PVR. Nevertheless the method is subject to inaccuracies, if the person performing the catheterization is not fully instructed as to the procedures and techniques to assure complete emptying (moving the catheter in and out slowly, twisting it, suctioning with syringe, suprapubic pressure), especially in cases of bladder diverticula and vesicoureteric reflux [2]. Stoller and Millard [3] showed inaccuracies in 30% of 515 male patients evaluated by full-time urological nurses with a mean difference between the initial and the actual residual volume of 76 ml in 30 % of inaccurate assessments. After further education of the nurses, inaccurate assessments were reduced to 14% with a mean difference of 85 ml.

PVR can be measured at the time of endoscopy, provided there is a blinded insertion of the instrument to avoid irrigation fluid inflow.

Both invasive means require local anaesthesia and carry the risk of urethral damage and urinary infection.

Before the era of ultrasonography, PVR was measured non-invasively by the phenolsulfonphthaleine excretion test [4] or with isotopes [5].

Ultrasound is the least invasive method of determining the PVR. There are several methods for its estimation based on transverse and longitudinal ultrasound bladder imaging. Using either three diameters (length, height, width) or the surface area in the transverse image and the length obtained in the longitudinal image, various volume formulae for a spherical or a ellipsoid body are utilised to estimate the bladder volume (Table 4).

All five formulae are equally good in assessing residual urine (93.6% concordance). Currently, no single formula can be indicated as the one best volume calculation formula.

Several studies report a sufficient accuracy in the ultrasound estimation of PVR [13 - 19]. False negative results are rare with PVR less than 20 ml [20] (Roherborn et al).

The intra-individual variability of PVR is high from day to day and even within a 24 hour period. This was reported in men with BPH by Birch et al [6] and by Bruskevitz et al [21]. Griffiths et al [22] examined the variability of PVR among 14 geriatric patients (mean age 77 years), measured by ultrasound at three different times of day on each of two visits separated by 2-4 weeks. Within-patient variability was large (SD 128 ml) because of a large systematic variation with time of day, with greatest volumes in early morning. The inherent random variability of the measurement was much smaller (SD 44 ml).

Several factors can influence PVR variability: voiding in unfamiliar surroundings, voiding on command with a partially filled or overfilled bladder, the interval between voiding and the estimation of residual (it should be as short as possible), the presence of vesicoureteric reflux or bladder diverticula.

Several studies [23 - 28] reported the questionable value of PVR as an important outcome prognosticator in male patients with benign prostatic enlargement and benign prostatic obstruction. There was no correlation of PVR with symptoms, size of the prostate and severity of outflow obstruction.

Table 4 : Comparison of different formulae to assess PVR by transabdominal ultrasound (Birch et al) in 30 men with BPH scanned three times

Author/reference	Method	Standard error	(%) 95% Confidence limits
Hakenberg et al	625 x H x W x (D1 + D2) / 2	17.5	34.3
Poston et al	7 x H x W x D1	20.0	39.2
Hartnell et al	625 x H x W x D1	17.0	33.3
Rageth & Langer	Nomogram based on areas	15.0	29.4
Orgaz et al	12.56 x H x r	12.9	25.5

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Recently portable scanners were introduced, with automatic measurement of bladdder volume. In a prospective comparison [29] of one hundred measurements of PVR by portable ultrasound with measurements by catheterisation, the mean absolute error of the scanner was 52 ml. For volumes below 200 ml and 100 ml, the error was 36 ml and 24 ml respectively.

There are no specific studies on the use of PVR measurement in the assessment of urinary incontinence.

Residual urine is usually referred as an absolute value, but it can be measured also as a percentage of bladder capacity.

1. Conclusion

There is little knowledge of the aetiology and the meaning of PVR, particularly on its relation with upper tract dilation and with bacteriuria and urinary infection.

There is a lack of data on PVR in patients with various kinds of urinary incontinence.

PVR has significant intra-individual variability and is often non reproducible, due to technical errors in measurement and to still uncompletely clarified physiological variations.

Ultrasound is the least invasive method and is sufficiently accurate for clinical purposes, yet is the most expensive. In-and-out catheterization is invasive and can be inaccurate even if carefully performed.

The general opinion is that PVR measurement forms an integral part of the study of urinary incontinence, as a safety parameter to exclude a voiding efficiency disorder associated with incontinence.

2. Recommendations

1. Residual urine measurement is recommended in the initial assessment of urinary incontinence as a safety parameter and in the evaluation of treatment outcome (**Low Level Evidence- Unanimos agreement**)
2. The determination should be performed utilising realtime sonography or portable scanner or in-and-out catheterisation (**Unanimous agreement**).
3. Due to intra-individual variability, in cases where significant PVR is detected by the first measurement, several measurements should be performed (**High Level Evidence**)
4. The modality of measurement should be indicated (Unanimous agreement).

3. Suggested research areas

1. Aetiology of residual urine
2. Presence and prevalence of residual urine in various incontinent populations
3. Physiological variability and diurnal variation of residual urine
4. Validation of the role of PVR measurement in the assessment of urinary incontinence
5. Determination of the cutoff value of significant residual urine
6. Residual urine as a prognostic indicator of outcome after treatment of incontinence

II. OPEN BLADDER NECK AND PROXIMAL URETHRA AT REST

Reports in the peer reviewed literature suggest that the open bladder neck and proximal urethra at rest, during the storage phase, can be observed during cystography, videourodynamics or bladder ultrasound, both in patients with and without neurologic disease.

Distal spinal cord injury have been associated with an open smooth sphincter area, but whether this is due to sympathetic or parasympathetic decentralization or defunctionalization has never been settled [1]

Relative incompetence of the smooth sphincter area may also result from interruption of the peripheral reflex arc very similar to the dysfunction observed in the distal spinal cord injury. Twenty-one out of 54 patients with spinal stenosis were found to have an open bladder neck at rest [2].

In a review on 550 patients [3], 29 out of 33 patients with an open bladder neck had neurologic disease. Although the association was more commonly seen in patients with thoracic, lumbar and sacral lesions, the difference when compared to cervical and supraspinal lesions was not significant. Damage of sympathetic innervation to the bladder was also frequently observed in patients undergoing major pelvic surgery, such as, abdominal perineal resection of the rectum.

Patients with myelodysplasia had an inordinately high incidence of open bladder neck (10 out of 18 patients. versus 19 out of 290 having different neurological disorders).

Patients with sacral agenesis are included in the larger category of myelodysplastic patients and suffer from an open bladder neck with an areflexic bladder.

Shy-Drager syndrome is a Parkinson-like status with peripheral autonomic dysfunction. Detrusor hyperreflexia is usually found in association with an open bladder neck at rest and a denervated external sphincter [4].

Peripheral sympathetic injury results in an open bladder neck and proximal urethra from a compromised alpha-adrenergic innervation to the smooth muscle fibres of the bladder neck and proximal urethra [5]. Although it can occur as an isolated injury it is usually associated with partial detrusor denervation and preservation of sphincter EMG activity.

The loss of bladder neck closure suggests an autonomic neural deficit. The site and nature of the requisite deficit is unclear. Most of the authors agree on the importance of the sympathetic system in maintaining the integrity of the bladder neck [6 - 10] although the possible role of parasympathetic innervation has been proposed by others [11] [12].

An open bladder neck at rest in children or in women without neurologic disease can represent a different disorder, either related to a congenital anomaly or secondary to an anatomical pelvic floor defect. Stanton and Williams [13] described an abnormality in girls with both diurnal incontinence and bed-wetting, based primarily on micturating cystourethrography, in which the bladder neck was wide open at rest. Murray et al [14] reported the "wide bladder neck anomaly" in 24.5% of the girls (35) and 9.3% of the boys (10) out of 251 children (143 girls and 108 boys) undergoing videourodynamics for the assessment of non-neuropathic bladder dysfunction (mainly diurnal incontinence). The authors considered the anomaly congenital and made the hypothesis that wide bladder neck anomaly in girls may provide a basis for the development of genuine stress incontinence in later life.

Chapple [15] reported that 21% per cent of 25 totally asymptomatic women he investigated by transvaginal ultrasound had an open bladder neck at rest. Versi [16] found a 21% prevalence of open bladder neck at rest in 147 women presenting to a urodynamic clinic and suggested that the finding is of little consequence.

Open bladder neck is a key point in defining type III stress incontinence according to the classificaton of Blaivas and Olsson [17]. This classification is based on history, imaging, and urodynamics, and distinguishes five diagnostic categories of stress incontinence. Incontinence type III is diagnosed by the presence of an open bladder neck and proximal urethra at rest in the absence of any detrusor contraction suggesting an intrinsic sphincter deficiency. The proximal urethra no longer functions as a sphincter. There is obvious urinary leakage which may be gravitational in nature or associated with minimal increase in intravesical pressure.

In pelvic fracture with membranous urethral distraction defects, when cystography (and/or cystoscopy) reveals an open bladder neck before urethroplasty, the probability of postoperative urinary incontinence may be significant, although the necessity of a simultaneous (or sequential) bladder neck reconstruction in controversial [18 - 20].

1. Recommendations

When observing an open bladder neck and proximal urethra at rest, during the storage phase, whatever imaging technique is used, it may be worthwhile to evaluate the possibility of an underlying autonomic neural deficit. (***Intermediate Level Evidence- Unanimous agreement***)

2. Suggested research areas

1. Relate the open bladder neck and proximal urethra at rest to the underlying neurogenic disorder
2. Longitudinal study of wide bladder neck and proximal urethra at rest in asymptomatic women
3. Evaluate the prognostic value of the open bladder neck and proximal urethra at rest

III. BLADDER WALL THICKNESS

Mean bladder wall thickness measurement of the empty bladder (< 50 ml) by means of transvaginal ultrasound has been found to discriminate between women with diagnosed detrusor instability and those with genuine stress incontinence [1] (Khullar et al, 1994) (Figure 27). All the women with detrusor instability had a mean bladder wall thickness greater than 5 mm.

Applying this test to a cohort of 180 female patients and using a bladder wall thickness greater than 5 mm as a screening test for detrusor overactivity, the sensitivity and the specificity were 84% and 89% respectively. The positive predictive value of diagnosing detrusor instability in women with a mean bladder wall thickness greater than 5 mm was 94%, compared to 61% for videourodynamics. The positive predictive value of a mean bladder wall thickness of less than 3-5 mm for diagnosing the absence of detrusor instability was 82%, compared to 76% for videourodynamics [2] (Khullar et al, 1996).

The association between thickening of the bladder wall (> 5 mm) and detrusor instability in nonobstructed women is striking and this diagnostic approach deserves confirmation of its value.

1. Suggested research areas

Diagnostic role of bladder wall thickness in female urinary incontinence (**Low Level Evidence**)

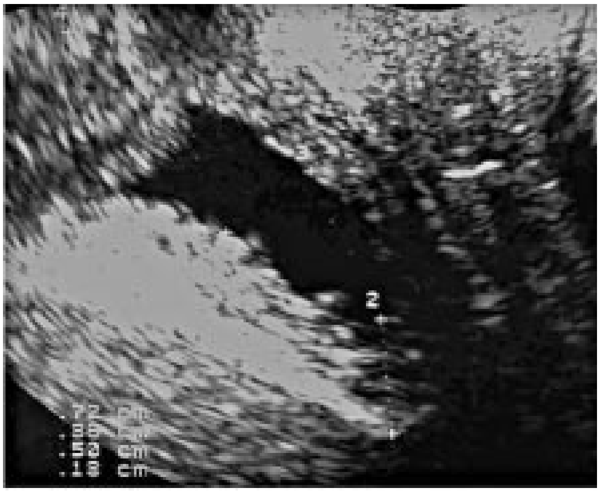

Figure 27 : Sonographic bladder wall thickness

IV. FEMALE URETHRAL DIVERTICULA

The first case of female urethral diverticulum was reported in 1805 [1]

Since the report from Davis and Cian in 1956 [2] using positive-pressure urethrography, the diagnosis has become much more common even though, despite increased clinical awareness, this pathology continues to be frequently overlooked.

Urinary incontinence is frequently associated with a urethral diverticulum. Incontinence may be a sequel to urine loss from the diverticulum itself with stress manoeuvres, genuine stress incontinence or urge incontinence [3]. Aldrige et al [4] reported urethral diverticula in 1.4% of patients with stress urinary incontinence.

The presenting symptoms of a urethral diverticulum have classically been described as the three Ds (Dysuria, postvoid Dribbling, and Dyspareunia). Since most patients present with nonspecific lower urinary tract symptoms, and the pathognomonic presentation (post-void dribbling, urethral pain, tender periurethral mass and expression of pus form the urethra) is very uncommon, these patients undergo extensive evaluation and treatment before a correct diagnosis is established [5,6].

The diagnosis of a urethral diverticulum may be achieved by physical examination, voiding cystourethrography, positive-pressure (double-balloon) urethrography, urethroscopy, endocavitary (transurethral or transvaginal) or transperineal ultrasound sonography, urethral pressure profile or MRI.

Positive pressure urethrography is usually accomplished using a double balloon catheter according to the method described by Davis and Cian [2]. Two different models exists: the Davis-TeLinde and the Tratner catheter. Positive-pressure urethrography (and voiding urethrography) may result in a false negative study when the inflammation of the diverticulum neck prevents contrast medium to flow into the diverticulum cavity. Ultrasound sonography and MRI should be theoretically free of such false negative imaging. Chancellor et al [7] described the use of intraoperative intraluminal echographic evaluation.

A number of studies have shown that MRI is a superior image modality to both voiding cystourethrography and positive-pressure urethrography and can be considered, if available, the imaging of choice when the diagnosis of urethral diverticulum is suspected [8 - 13] (Figure 28 a,b). MRI provides information on location, number, extent (simple vs. saddle-bag) and size of diverticula. Endoluminal MRI with either a vaginal or rectal coil, may provide even better image quality than simple MRI [12].

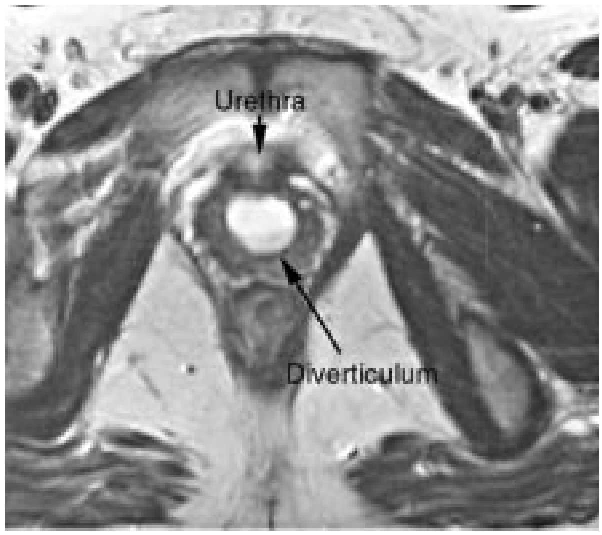

Figure 28 a : MRI: urethral diverticulum (coronal view)

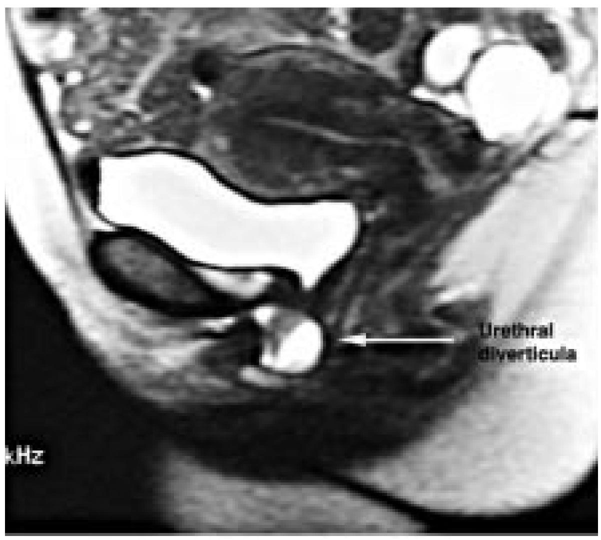

Figure 28 b : MRI: urethral diverticulum (sagittal view)

A comparison of MRI versus urethrography and urethroscopy, in a group of 20 women with urethral diverticulum, reported a 69 and 77 per cent accuracy of the two latter imaging studies versus MRI [8]. When surgical findings were compared to MRI, urethrography and urethroscopy, the diagnostic ability of the three methods was 70, 55 and 55 per cent, respectively. Diverticular ostia could not be identified by MRI study notwithstanding the use of contrast material.

Neitlich et al [9] reported in a series of 19 patients that MRI (using a fast spin echo T2-weighted pulse sequence and a dedicated pelvic multicoil) had a higher sensitivity for detecting urethral diverticula and a higher negative predictive rate in comparison with double balloon urethrography. Blander et al [11], comparing MRI and VGUG in 27 patients with urethral diverticula, found that endoluminal (endorectal or endovaginal) MRI was extremely accurate in determining the size and extent of urethral diverticula compared to VCUG; the related information can be critical when planning surgical approach, dissection and reconstruction.

In conclusion, review of the peer reviewed literature suggests that positive pressure urethrography is still a valuable tool to diagnose female urethra diverticula notwithstanding both ultrasound sonography and particularly MRI can represent valuable alternatives with a significantly higher diagnostic accuracy.

1. Recommendations

In cases of female urinary incontinence if a urethral diverticulum is suspected, appropriate imaging (positive pressure urethrography, voiding cystourethrography, urethroscopy, ultrasound, MRI) is recommended. (The choice of the type of imaging depends on their availability. Data show a higher accuracy of MRI.) (**Intermediate Level Evidence- Unanimous agreement**)

C. IMAGING OF THE NERVOUS SYSTEM (NEURO-IMAGING) IN URINARY INCONTINENCE

I. LUMBOSACRAL SPINE X-RAYS

Lower urinary tract dysfunction with urinary incontinence in children can be the expression of an underlying spinal dysraphism. In the majority of cases, abnormalities of the gluteo-sacral region and/or legs and foot are visible, but there can be cases where the abnormalities are minimal or absent. A careful evaluation of the anteroposterior and lateral film of the lumbosacral spine can identify vertebral anomalies commonly associated with nervous system anomalies.

Sacral agenesis involves the congenital absence of part or all of two or more sacral vertebrae. In the absence of two or more sacral vertebrae a neurogenic bladder is the rule.

Spina bifida occulta has a variable significance. Simple failure to fuse the laminae of the fourth and fifth lumbar vertebrae is unlikely to be important, but if the spinal canal is noticeably widened, there may be cord involvement (diastematomyelia, tethered cord syndrome).

1. Recommendations

In patients with suspected congenital neurogenic incontinence, with or without abnormalities of neurourologic physical examination, lumbosacral spine anteroposterior and lateral radiological evaluation (or MRI) is indicated. (**Intermediate Level Evidence- Unanimous agreement**)

II. CT, MRI, SPECT and PET (CNS)

Imaging of the central nervous system (CNS) is a valuable aid in the diagnosis of a variety of CNS diseases which may cause urinary incontinence.

Computerised tomography , magnetic resonance imaging , single photon emission computed tomography (SPECT), and positron emission tomography (PET) have been used and reported in the literature.

When urinary incontinence is just one of the many symptoms caused by a CNS disease, the diagnosis is made on clinical grounds and CNS imaging is carried out only to confirm it. In rare cases, urinary incontinence is the presenting symptom of an underlying neurologic disorders and CNS imaging is instrumental in the diagnosis.

The peer reviewed literature is an endless list of rare neurological conditions presenting with different symptoms including urinary incontinence in which CT scan, MRI, SPECT, and PET imaging were carried out identifying the underlying CNS disease.

After a cerebrovascular accident, the urodynamic behaviour of the lower urinary tract has been correlated to CT pictures of the brain [1,2].

The presence of significant cerebral lesions has been clearly demonstrated by CT, MRI or SPECT in the absence of clinical neurologic symptoms and signs in patients complaining of urge incontinence [3]. This can be particularly significant in elderly patients. Griffiths et al [4], studying 48 patients with a median age of 80 years, reported that the presence of urge incontinence was strongly associated ($P = 0.009$) with depressed perfusion of the cerebral cortex and midbrain as determined from the SPECT scan.

Kitaba et al [5] using MRI reported subclinical lesions in the brain in 40 out of 43 men more than 60 years old who complained of urinary storage symptoms; of these 40 patients, 23 (57.5%) had detrusor hyperreflexia.

Positron emission tomography (PET) studies provided information on specific brain structures involved in micturition in humans. In men and women who were able to micturate during scanning, an increase in regional blood flow was shown in the dorsomedial part of the pons close to the fourth ventricle, the pontine micturition center (PMC). PET studies showed also the activation during micturition in men and women of the mesencephalic periacqueductal grey (PAG) area. This area is known from cat experiments to project specifically to PMC and its stimulation elicits complete micturition; experimental interruption of fibers from the PAG to the PMC results in a low capacity bladder. PET studies during micturition in humans showed also an increased regional blood flow in the hypothalamus included the preoptical area which in cats can elicit bladder contractions [6, 7]

These functional CNS imaging studies have a great potential to improve our knowledge on nervous functional anatomy related to vesicourethral function and dysfunction.

1. Conclusion

CNS imaging is rarely indicated in urinary incontinence.

In the advent of clinical neurological signs and/or symptoms suggestive of central nervous lesions, imaging may be indicated along with more specific neurophysiological tests (e.g. signal latency testing, evoked potential etc.).

A better knowledge of the correlation between morphologic and functional evaluation of the CNS is foreseeable using present CNS functional imaging technology.

2. Recommendations

Neuro-imaging should be considered when a nervous system disorder is suspected on the basis of clinical and/or neurophysiological test findings. (**Intermediate Level Evidence-Unanimous agreement**)

3. Suggested eesearch areas

Correlation of CNS functional morphology to pathophysiology of urinary incontinence.

D. ENDOSCOPY OF THE LOWER URINARY TRACT

I. BACKGROUND

Since the introduction of the cystoscope in the early nineteenth century, endoscopy has played a growing and critical role in the evaluation of certain lower urinary tract diseases. Many investigators have recommended the routine use of urethrocystoscopy in the evaluation of urinary incontinence. In many cases these recommendations have been based on the individual investigators own feelings on the usefulness of the technique. However, rarely is specific data presented to support the recommendations.

There are four specific areas pertaining to urinary incontinence in which cystourethroscopy has been advocated:

1. Observation of the female urethral sphincteric unit to assess its ability to close and coapt. Urethrocystoscopy has been advocated in the static state to assess for intrinsic sphincter deficiency (ISD) as well as in the dynamic state, when the patient is straining, to evaluate hypermobility and urethral closure while the patient is straining. It has been reported that sluggish closure of the bladder neck during periods of a rise in intra-abdominal pressure is associated with anatomical stress urinary incontinence. Intrinsic sphincter deficiency has classically been described as a fibrotic or pipe-stem urethra. It has been suggested that endoscopy can even help to differentiate between the hypermobile urethra and the intrinsically damaged urethra.

2. Assessment of the bladder, to rule out an intravesical lesion or process that may occur concomitantly with incontinence or that may be a cause of irritability or instability.

3. Determination of extraurethral causes of urinary incontinence, such as, vesico-vaginal fistula and ectopic ureter.

4. Intraoperatively during operative correction of genuine stress incontinence

to assess for ureteral patency, intravesical foreign bodies or bladder damage.

5. Evaluation of the membranous and prostatic urethra in the male with urge incontinence (presumed to be secondary to bladder outlet obstruction or benign prostatic hyperplasia (BPH)), overflow incontinence, or post-prostatectomy incontinence.

II. EVALUATION OF THE FEMALE BLADDER OUTLET

Robertson described the procedure of dynamic urethroscopy to evaluate the bladder neck [1]. In this procedure a gas urethroscope is used to observe the urethra, bladder neck, and portions of the bladder. During visualisation manometric recording can be performed. Robertson described the appearance of true stress incontinence as a sluggish closure of the bladder neck and the appearance of the unstable bladder as a bladdder neck that closes and then opens like the shutter of a camera. This procedure was reported to be extremely useful in patients with urinary incontinence as the bladder neck can then be observed at rest, with straining, and Valsalva manoeuvres. Unfortunately, in Robertson's original description of this procedure, it was never compared to other standard methods of measuring outlet resistance. Others who advocate the technique of Robertson reported that only 43% of patients with stress incontinence actually had loss of bladder neck support on urethroscopy [2].

Scotti, et al performed a retrospective review of 204 patients who underwent dynamic urethroscopy for the evaluation of genuine stress urinary incontinence [3]. Of the 204 patients, 99 had genuine stress urinary incontinence confirmed by urodynamic testing. Urethroscopy was found to be an imprecise predictor of genuine stress urinary incontinence with a 62% sensitivity, a 74.6% positive predictive value and a specificity of 79.1%. Moreover, there were many equivocal studies. The authors concluded that urodynamic evaluation rather than urethroscopy was a more accurate predictor of genuine stress incontinence.

Horbach and Ostergard tried to predict urethral sphincter insufficiency in women with stress urinary incontinence using urethroscopy [4]. They retrospectively reviewed the records of 263 women who had a diagnosis of genuine stress urinary incontinence. They defined ISD as a maximal urethra closure pressure of 20 cm H2O or less with the patient upright with a symptomatically full bladder. They then divided patients into two groups, those with ISD and those with maximal urethral closure pressures of more than 20 cm H2O. Based on this classification, 132 women, or 50.2%, had evidence of ISD. However, when urethral function was assessed by endoscopy, only six of 132 patients with ISD were found to have an open or partially open proximal urethra and urethrovesical junction at rest during urethrocystoscopy. Clinically, these patients had very low urethral pressures and reported difficulty with continuous leakage of urine. Endoscopy appeared to have little predictive value for ISD as defined by urethral pressure profilometry.

Govier et al compared cystoscopic appearance of the female urethral sphincteric mechanism to the videourodynamic studies in 100 consecutive women with complex types of urinary incontinence [5]. Sphincteric dysfunction was classified as minimal, moderate, and severe based on the radiographic appearance of the bladder neck with straining. Urethrocystoscopy underestimated the degree of sphincter deficiency 74% of the time in patients with moderate sphincteric dysfunction and 44% of the time in patients with severe sphincteric dysfunction. The authors conclude that cystoscopy is inadequate to judge the functional integrity of the bladder outlet. Furthermore, cystoscopy alone will underestimate intrinsic sphincter deficiency in a large number of patients.

With respect to detrusor instability, characteristic urethroscopic findings of "a vesicle neck that closes and then opens like the shutter of a camera", have been described [1] Sand, and associates compared supine urethroscopic cystometry (dynamic urethroscopy) to the gold standard of multichannel urethrocystometry [6]. They found a sensitivity of only 24.6% and a positive predictive value of only 65.2% in predicting detrusor instability.

III. EVALUATION OF THE BLADDER

Is cystoscopy necessary to rule out concomitant bladder pathology in patients with urinary incontinence?

Langmade and Oliver reported on 253 patients who were operated on for stress urinary incontinence [7] They used a simple evaluation that consisted of history, stress tests, and urinalysis alone. They did, however, recommend cystoscopic evaluation if the patient also complained of symptoms of urgency. Although this dogmatic approach was recommended, it was never clearly stated if it made a difference in the treatment or outcome in these patients. Fischer-Rasmussen, et al performed extensive evaluation of women with urinary incontinence [8]. This included cystoscopy in 190 patients. They found cystoscopy to be abnormal in only 12 patients, 8 who had stress incontinence and 4 who had other types of incontinence. Abnormal findings were trabeculated bladder mucosa in five patients, benign bladder papillomas in four, and metaplasia of the trigonal mucosa in two. None of these was considered to be a significant finding. The authors concluded that cystoscopic examination did not contribute to the classification of incontinence in any case.

Cardozo and Stanton evaluated 200 patients with stress incontinence and detrusor instability [9] Cystoscopy revealed no abnormalities amongst the 100 patients with genuine stress urinary incontinence. Fourteen of the 100 patients with detrusor instability had cystoscopic abnormalities, eg trabeculation-11, injected mucosa-1, sacculation –1, a bladder capacity of less than 100 cc-1. However, in none of these patients was the treatment affected by the results of cystoscopy.

In support of these findings, Mundy has stated that there is no direct diagnostic value of endoscopy in a patient with an unstable bladder. It may sometimes be helpful to look for and exclude a cause of hypersensitivity when this is in the differential diagnosis.[10] Dulaosal and colleagues found this necessary only in patients with hematuria. [11]. They performed urinalysis, urine cytology, and cystoscopy on 128 women who presented with urge incontinence and/or irritative voiding symptoms. Of these, 68 patients had urge incontinence, 35 of whom also had microscopic haematuria. One patient with urge incontinence and haematuria was found to have a transitional cell carcinoma of the bladder. None of the patients with urge incontinence (or irritative symptoms only) and no haematuria was found to have significant cystoscopic findings. This would support the routine use of cystoscopy for patients with urge incontinence only if hematuria is present.

IV. EXTRA-URETHRAL URINARY INCONTINENCE

Endoscopy can be an invaluable tool in the diagnosis and treatment of extraurethral incontinence due to vesico-vaginal fistula and ectopic ureter. With respect to vesico-vaginal fistula, cystoscopy can precisely localize the fistula site in the bladder and help plan surgical correction. Occasionally, a small fistula that is not seen on physical examination or by radiographic studies, can only be diagnosed by cystoscopy.

Incontinence due to ectopic ureter in the female is usually diagnosed by radiographic studies. However, the exact location of the ureteral orifice in the urethra or vagina can be identified by cystourethroscopy and/or vaginoscopy. This can be extremely helpful in the planning of corrective surgery.

V. INTRAOPERATIVE LOWER URINARY TRACT EVALUATION

Several authors have studied the value of routine cystoscopy during operative procedures for incontinence and prolapse. The approach may be transurethral [12] or transvesical [13]. The American College of OB/GYN has published a Bulletin on Operative Lower Urinary Tract Injuries [14] in which is stated "at the conclusion of the procedure, when hemostasis has been ensured, both ureters and the bladder should be inspected to confirm their integrity."

Harris, Cundiff, Theofrastous, et al [12] reported 9 unsuspected ureteral or bladder injuries during urogynecological surgery, which included 6 ureteral ligations, with four of these occurring after Burch cystourethropexy. Burch sutures were also found in the bladder as well as fascial lata from a sling procedure.

VI. EVALUATION OF THE MALE BLADDER OUTLET

Urge incontinence is one of the lower urinary tract symptoms associated with benign prostatic hyperplasia, bladder outlet obstruction, and aging in the male population. Based on the available evidence and world literature, The World Health Organization Fourth International Consultation on BPH made the following recommendation:

"Diagnostic endoscopy of the lower urinary tract is an optional test in the standard patient with LUTS (lower urinary tract symptoms) because:

1. the outcomes of intervention are unknown

2. the benefits do not outweigh the harms of the invasive study

3. the patients' preferences are expected to be divided

However, endoscopy is recommended as a guideline at the time of surgical treatment to rule out other pathology and to assess the shape and size of the prostate, which may have an impact on the treatment modality chosen [15].

Several contemporary series have described the value of urodynamics in the diagnosis of post-prostatectomy urinary incontinence [16,17,18,19,20]. However, only one describes the routine use of urethrocystoscopy. In that series 67% of patents had urethral fibrosis confirmed by endoscopy [17]. However, how this finding effected treatment was not discussed. In the study by Leach and Yun treatment of incontinence was based solely on urodynamic findings and was successful in 87% of patients [21]. Anastomotic strictures may be suspected based on uroflow and urodynamic (pressure-flow) studies and can be confirmed by voiding cystourethrogram or videourodynamics as well as by endoscopy. However, if intervention for the stricture is deemed necessary, endoscopy would be a more critical part of the evaluation. Furthermore if surgical treatment of incontinence, such as, an artificial urinary sphincter, is planned it would seem to make good clinical sense to evaluate the urethro-vesical anastomosis with endoscopy prior to surgery.

VII. RECOMMENDATIONS

1. Routine urethro-cystoscopy is NOT indicated in primary female urinary incontinence, when other pathologies are not suspected(**Intermediate Level Evidence- Unanimous agreement**).

2. Endoscopy can be considered(**Intermediate Level Evidence-Unanimous agreement**):

a) in urge incontinence to rule out other pathologies, especially in case of microscopic haematuria (e.g., bladder tumor, interstitial cystitis, etc)

b) in the evaluation of recurrent or iatrogenic cases when surgery is indicated and planned

3. Endoscopy is indicated in the evaluation of vesico-vaginal fistula and extra-urethral urinary incontinence (**High Level Evidence**).

4. Endoscopy is indicated intraoperatively in incontinence surgery to evaluate for ureteral or vesical injury (**High Level Evidence**).

VIII. SUGGESTED RESEARCH AREAS

To relate endoscopic features to diagnosis and outcome of urinary incontinence (mainly urge incontinence)

E. PAD TESTING

I. BACKGROUND

Quantitative measurement of urine leakage by using a perineal electronic nappy was first described by James et al. (1971). This innovation incorporated electrical conductivity into the nappy to facilitate estimation of the urine loss (Caldwell, 1974). Accuracy of this technique was, however, questioned by others (James & Flack, 1974; Rowan et al., 1976; Stanton, 1977; Wilson et al., 1980; Eadie et al., 1983). This was later improved by Mayne & Hilton (1988). Simple measurement of the gain in weight of perineal pads to estimate leakage was introduced by Sutherst et al. (1984) and Walsh & Mills (1981). These tests were, however, not well standardised. Bates et al. (1983) - Bristol ICS Committee on Standardization of terminology- described the one hour pad test in a more structured way and this was later endorsed by the International Continence Society in 1988 (Abrams et al.). This test, however, was shown to have poor interdepartmental correlation (Christensen 1986) and to be highly dependent on bladder volume (Lose et al., 1986). Further, 24 hour and 48 hour pad tests administered at home were developed. They showed a better estimation, but they were more cumbersome. Pyridium was also used (Wall et al. 1990). Janez et al 1993 tried to compare distal urethral electric conductance (DUEC) with the pad test (not well defined) and found both tests equal. A good review of the Pad Test was published by Ryhammer et al., in 1999.

II. DEFINITION

The pad test is a method of quantification of urine loss based on the measurement of weight gain of absorbent pads during a a test period under standardized conditions.

III. INDICATION AND METHODOLOGY

A test is indicated if quantitative analysis of the urine loss is required. Several different standards were developed. Generally tests can be divided in four groups: <1h, 1h, 24h and 48 h. (Table 5).

IV. QUALITY OF DATA

1. A SHORT PAD-TEST

a) Quantification

Jakobsen et al. (1987) found that the 40 minute test with an initial bladder volume of 75% of maximum cystometric capacity and similar activities as with a 1-hour ward test produced consistently larger amounts of urine loss as compared to a standard 1-hour ward test. The difference was attributed to significantly larger bladder volumes during performance of physical activity in a 40 minute pad test.

Kinn & Larsson (1987) reported no correlation between a short 10 minute test with fixed bladder volume and the degree of incontinence as judged from the symptoms.

Hahn & Fall (1991) in a 20 minute test with half cystometric capacity showed no false negative results in 50 women with stress urinary incontinence although there was some discrepancy (in 12% of patients) between the patients' perception of the degree of incontinence and pad test results.

Table 5 : Pad testing

Author	Time	Bladder load	Exercises
Hahn & Fall	20 min	0% of MCC	stair climbing, 100 steps, coughing (10x), running (1 min), wash hands (1 min) jumping(1 min)
ICS	1h	Drink 500 ml (15 min) before test	walking & stair climbing (30 min), standing up 10x, coughing (10x), running (1 min), bending (5x), wash hands (1 min)
Jorgensen et al	24h		Everyday activities
Jakobsen et al.	48h		Everyday activities

b) Reproducibility

The correlation factor (Pitman's nonparametric permutation test) between two separate 20 minute tests was 0.94 ($p<0.001$) (Hahn & Fall 1991). Kinn et al (1985) and Kinn & Larsson (1987) showed that the 10 minute test with a fixed pre-test bladder volume of 75% of maximal capacity was fairly reproducible ($r=0.74$).

2. One-hour test

a) Quantification

Walsh & Mills (1981) in elderly and Holm-Bentzen et al (1985) in patients with an AMS artificial sphincter showed that the one hour pad test did not correlate with subjective patient satisfaction. In an elderly population a one-hour ward test failed to demonstrate incontinence in 66% patients which complained of incontinence in comparison to a 24 hour home test which showed only a 10% false negative rate (Griffiths et al. 1991). Jakobsen et al. (1987) reported that one hour test was inferior in regard to the amount of urine loss (3 g) to 40 minute (7 g) and a 48 hour pad test (37 g). A one hour pad test was found to reflect everyday incontinence in only 48% of the patients in comparison to 81% in a 48 hour test and 77% in a 40 minute test. Jorgensen et al. (1987) remarked that only 10% did not complete the test (mean age 55 years of age) and 69% of the patients indicated that the test results correlated with daily leakage. Mayne & Hilton (1988) carried out a 1-hour pad test (n=33 patients with SUI) at a specific bladder volume (250 ml) and increased the detection rates of urine leakage (T=+92) vs. a standard 1 hour ward test (T=+62). Statistical analysis was done using Wilcoxon sign-rank test for nonparametric data. Kralj (1989) found the one-hour test to correlate with history of stress urinary incontinence in 47% (specificity 0.45) and with urge incontinence in 46%. Low correlation was attributed to small bladder volume (102 ml) during the test. Lose et al. (1989) demonstrated in 31 women a 58% correlation of the modified one-hour test (200-300 ml in the bladder) with the history of stress urinary incontinence. Mouritsen et al. 1989 (n=50) showed that a 1-hour ward pad test did not detect grade I stress incontinence in 46%, grade II in 27% and grade III in 66%. Thind & Gerstenberg (1991) compared a 1-hour ward pad test to a 24-hour home pad test and found that a 1-hour pad test had a 36% false-negative rate as compared to a 24-hour home pad test. Martan et al. (1992) found in 85 patients with incontinence that a modified 1-hour test at 75% of bladder capacity was positive in 44%.

b) Reproducibility

Klarskov & Hald (1984) demonstrated in 3 consecutive 1-hour pad tests, a correlation coefficient of 0.75 and 0.97 depending on the activity regime. The test, however, was quite demanding and a lot of patients did not complete the full testing. Christensen et al. (1986) compared a one-hour pad test in two different urological and one obstetrics & gynecological departments (20 women). The test results in two urological departments did not differ with an average pad gain of 24g and 21 g ($p>0.1$). However, pad test results between the departments of urology and gynecology differed significantly, with average pad weight gain 9g and 24 g respectively ($p<0.05$).

Kralj 1989 showed the repetitveness of a standard one-hour test to be 79%. Repetitiveness of the 2/3 bladder volume test was 84.2% and the full bladder test was 89.4% (n=418)

Lose et al. 1986 showed a significant variation between 1-hour ward test and retest in 18 patients (correlation coefficient 0.68). In about 50% of patients the degree of leakage was diverse and attributed to difference in diuresis. When the results of the 1-hour pad test were corrected for urine volume, the correlation coefficient value increased to 0.96.

c) Bladder volume

Fantl et al (1987) showed that test-retest correlation (Pearson correlation coefficient) was high and further enhanced when fluid loss was expressed as a percentage ratio of bladder volume. They used a modified one-hour test in which the bladder was filled to capacity by gravity before exercises.

Jorgensen et al (1987) showed fairly good reproducibility (r=0.68, p<0.01). When the results were calculated taking into account volume at the test start, test-retest correlation was better (r=0.93; p<0.0001). Lose et al. (1988) when using a 1-hour pad test with standardised bladder volume of 50% of maximal cystometric capacity (MCC) showed in 25 women a test retest correlation of 0.97 (p<0.001). But there was a considerable variation up to 24g between the two tests. Kralj 1989 showed that a one-hour test at 2/3 of a bladder capacity had a 73% correlation to symptoms of stress urinary incontinence and a 61% correlation to symptoms of urge incontinence. The results differed slightly when the test was done at full bladder capacity with 63% correlation for stress incontinence and 73% for urge incontinence. Jakobsen et al. (1993) compared a 1-hour pad test with a bladder filled to 50% and 75% of maximal cystometric capacity and found that the final bladder volume was equal in both groups. An increased diuresis in the 50% group accounted for an equal bladder volume in both groups. The amount of leakage in both groups was the same.

d) Diagnosis

Fluid loss was significantly greater in patients with detrusor instability in comparison to pure SUI (Fantl et al. 1987, Prajsner & Radziszewski 1998). However, the large standard deviation indicated a considerable between patient variability making the test impractical as a diagnostic tool.

3. 2-HOUR PAD TEST

A period of 60-120 minutes after a 1 litre fluid load was identified as the most optimal for the pad test because of a consistently high bladder volume (Haylen et al 1988). Han et al (1996) showed, however, that a 1-hour pad test is more practical. In children a 2-hour ward pad test yielded 70% positive results for incontinence (Hellstrom et al. 1986). Kralj 1989 showed a 2-hour pad test repetitiveness of 64.2%. Richmond et al. (1987) compared two exercise regimes with a 2-hour pad test and showed no significant differences in regard to which order the exercises were performed. They also showed that a 2-hour test is better than a 1-hour one. Only 28% had a positive test after 1 hour in comparison to 100% after 2-h. Walters et al. (1990) performed a 2-hour pad test with standard exercise in 40 women with SUI. The results showed 78% positive tests (>1g pad gain) after 1 hour and 98% after the second hour. There was no correlation between pad test results and the severity of a symptoms score.

4. 12-HOUR PAD TEST

a) Quantification

Hellstrom et al. (1986) demonstrated in 30 children with incontinence a positive 12-hour home pad test in 68%. When fluid volume (13 ml/kg) was instituted in 20 children, the frequency of the positive test increased to 80%.

5. 24-HOUR PAD TEST

a) Quantification

Jorgensen et al. (1985) showed that a 24h home test performed during daily activities is more sensitive that a 1-hour ward test with standardised bladder volume of 200-300 ml. Out of 31 patients 13 were classified as continent according to a 1-hour ward test in comparison to only 3 with a 24-hour home pad test. Klevmark et al. (1988) used s “Combined Test” of a 24h pad test and a frequency-volume chart and suggested several advantages of this combination: diuresis can be monitored and controlled better, and calculation of the percentage of urine loss with respect to a 24 hour diuresis and diagnosis of urge incontinence can be better defined. Lose et al. (1989) demonstrated 90% correlation of a 24-hour pad test with history of stress incontinence in 31 women. This was better than the results of a 1-hour test. Mouritsen et al. (1989) showed that a 24-h home test is well tolerated and as good in detecting incontinence as a 48-h test. Griffiths et al. (1991) found only a 10% false negative rate of a 24-hour pad test in an elderly population. Using non parametric coefficient of correlation, they found a significant difference between the 1-hour test and the 24 hour test. High fluid intake did not change the results of a 24-h home test, but a low fluid intake reduced a positive test by 56% (Rasmussen et al. 1994). Ryhammer et al., (1998) showed that 24-h test is superior to subjective self-reported assessment of urinary incontinence.

b) Reproducibility

Jorgensen et al. (1985) showed a significantly positive correlation (r=0.82), p<0.001) between the results of the two 24-hour home tests. Lose et al 1989 showed, however, poor correlation between a test retest with a variation of more than 100%. Groutz et al., (2000) using Lin’s concordance correlation coefficient (CCC) found 24-h test very reliable instrument. Increasing test duration to 48 and 72 hours slightly improved reliability but decreased patient compliance.

6. 48-HOUR PAD TEST

a) Quantification

Jakobsen et al. (1987) showed that 48-hour pad test reflects everyday incontinence in 81% of patients. Kralj (1989) demonstrated 96% (0.92 specificity) agreement with history of incontinence but commented that it was done entirely by the patient without objective control. No statistical analysis data was given. Ekelund et al.,

Table 6 : Test-retest correlation

Author	Test	Correlation coefficient	Symptoms
Klarskov&Hald 1984	1-h	0.96	SUI&UUI
Mundt-Petterssen et al 1984	1-h F	airly good	SUI,UUI & MIX
Jorgensen et al. 1985	1-h	0.27	SUI & MIX
Lose et al 1986	1-h	0.68	SUI & MIX
Fantl et al. 1987	1-h (vol)	0.97	SUI
Fantl et al. 1987	1-h (vol)	0.84	SUI & UUI
Kinn et al. 1985	10-m (vol)	0.74	SUI
Lose et al. 1988	45-m (vol)	0.97	SUI & MIX
Victor et al. 1987	24-h	0.66	SUI
Lose et al. 1989	24-h	0.82	LUTS
Mouritsen et al. 1989	24-h	0.87	MIX
Versi et al. (1996)	24-h	0.9	LUTS
Groutz et al. (2000)	24-h	0.89	LUTS
Victor et al. 1987	48-h	0.9	SUI
Versi et al. (1996)	48-h	0.94	LUTS
Groutz et al. (2000)	48-h	0.95	LUTS

Table 7 : Pad-weight gains (g) in normal women

Author	Time	No	Mean (g)	From (g)	to (g)	SD	SEM	Note
Hahn & Fall 1991	20 min	10	0.0					
Nygaard& Zmolek, 1995	39.5 min	14	3.19	0.1	12.4	3.16		Exercise
Versi&Cardozo 1986	1h	90	0.39	0	1.15		0.04	
Sutherst et al. 1981	1 h	50	0.26	0	2.1	0.36		
Walsh & Mills, 1981	2h	6	1.2	0.1	4.0	1.35		Daily activity
Lose et al. 1989	24h	46	4.0	0	10			
Jorgensen et al., 1987	24h	23	4.0	0	10			
Mouritsen et al 1989	24h	25	2.6	0	7			
Versi et al 1996	48h	15	7.13			4.32		

(1988) found patients own weighing correlate well to control weighing at the clinic in 48-h pad test (r=0.99).

Nygaard and Zmolek (1995) in 14 continent women showed a mean pad weight, attributed to sweat for all exercises sessions of 3.19 $\pm$ 3.16 g (the Kendall coefficient of concordance of the test-retest reliability was 0.96) but there was a lot of variation between patients. Pyridium staining was not helpful in increasing specificity. Similar results with Piridium was reported by Wall et al. (1990) in a 1-hour ward test. In his study (n=18) the Pyridium test was 100% positive in patients with SUI but had false positive results in normal women (52%).

Mean pad weight loss due to evaporation or leakage (Walsh & Mills, 1981) was calculated to be 1.003 g, and ranged from -6.5 to +3.85 g (SD 1.85 g). Lose et al. (1989) showed no evidence of evaporation over 7 days if the pad was stored in a plastic bag. Versi et al. (1996) showed pads wetted with saline showed no difference in weight after 1 week and less than 10% weight loss after 8 weeks. Twelve pads were weighed by the patient and a healthcare worker with a coefficient of variance =1.55% with a mean deviation of 49%.

7. Comments

Khan & Chien (1996) eloquently pointed out that test-retest comparison should include methods of blinding and use of an appropriate index of degree of agreement which is the intra-class correlation coefficient. In most of the literature this was not implemented.

Kromann-Andersen et al (1989) argued that with considerable inter- and intra-individual variation of urine loss, the correlation of test/retest results may be overestimated and suggested different trials for small, modest and large leakage in large numbers of the patient.

8. Role of the investigation

The test has been standardised by ICS (1988) for quantification of urine loss and suggested uses for assessment and comparison of results of treatments of different types of urinary incontinence in different centers. Also, the AUA report on Surgical Management of Female Stress Urinary Incontinence includes a pad test (pretreatment evaluation) as a standard of efficiency for clinical trials (Leach et al., 1997). The Urodynamic Society included a pad test in a Standards of Efficacy for Evaluation of Treatment Outcomes in Urinary Incontinence (Blaivas et al., 1997). No suggestion was made in the last two reports of which test to use.

9. Summary

The 1-hour pad test is not very accurate unless a fixed bladder volume is applied

The sequence of exercises has little effect on test results

A pad weight gain $\geq$ 1 g = positive 1h test

A 24 hour test correlates well with symptoms of incontinence

A 24-hour test has good reproducibility

A pad weight gain >= 4g = positive 24 h test

A test lasting longer than 24 h has little advantage

A pad test cannot distinguish between stress and urge incontinence

V. RECOMMENDATIONS

1. The pad test is useful as an optional investigative tool in routine evaluation of urinary incontinence (**Intermediate Level Evidence- Unanimous agreement**)
2. Pad test is useful in clinical trials and research studies.

The following standards are suggested:

a) 20 min-1 h ward test with fixed bladder volume (pad weight gain >= 1g = positive test) (**Intermediate Level Evidence- Unanimous agreement**)

or

b) 24 h home pad test during daily acitivity (pad weight gain >= 4g/24h = positive test) (**Intermediate Level Evidence- Unanimous agreement**)

VI. SUGGESTED RESEARCH AREAS

1. Proper validation
2. Evaluation of the ability to detect all the spectrum of urinary incontinence (from mild to severe)
3. Sensitivity to change in time of incontinence status

F. OTHER INVESTIGATIONS

I. URINALYSIS IN THE EVALUATION OF THE INCONTINENT PATIENT

" The urinalysis is a fundamental test that should be performed in all urological patients. Although in many instances a simple dipstick urinalysis provides the necessary information, a complete urinalysis includes both chemical and microscopic analysis" [1]

In relation to urinary incontinence, urinalysis is not a diagnostic test, but a screening test, important in order to detect haematuria, glucosuria, pyuria and bacteriuria. Even in the absence of controlled studies, there is general expert consensus that the benefits of urinalysis clearly outweigh the costs involved, although the use of urinalysis should always be associated with prognostic significance [2]. A positive urinalysis will prompt infection treatment and/or the use of additional tests such as endoscopy and urinary tract imaging.

In the evaluation of urinary incontinence in the female, urinalysis is recommended since 60% of women with stable bladder will develop detrusor overactivity at the time of urinary tract infection (UTI). Pyuria was found to be common among incontinent but otherwise asymptomatic, female patients. Pyuria was not necessarily associated with UTI, the significance of sterile pyuria in the elderly population is still unclear [3]

A Norwegian survey of general practitioners' management of female urinary incontinence suggested that urinalysis is the most frequently performed test (73%) and is far more frequent than gynaecological examination (54%) [4]. Another survey suggested that urinalysis is one of the three-part assessment of UI together with patient history and physical examination [5]. The same apply, according to Stricker, for patient selection for collagen implant [6]. A minority of the reviewed papers suggested that urine culture should be carried out together with urinalysis [7,8]. Urinalysis is also considered of importance in the evaluation of nursing home residents who are incontinent [9], in peri- and postmenopausal women [10], in older women reporting urinary incontinence [11]. Belmin J, et al, suggested than significant urine samples can even be obtained from disposable diapers in elderly incontinent women [12].

It is recommended that geriatric incontinent patients undergo history, physical examination, tests of lower urinary tract function and urinalysis. The latter test is proposed to rule out the presence of UTI [13].

The clinical relevance of asymptomatic bacteriuria in the elderly is controversial, although many suggest this condition does not deserve any treatment. DuBeau and Resnick suggest the use of urinalysis in the diagnostic algorithm to identify asymptomatic bacteriuria in incontinent residents of nursing homes [14].

1. RECOMMENDATION

1. It is considered standard to perform a urinalysis either by using a dipstick test or examining the spun sediment. (***Unanimous agreement***)
2. If a dipstick test is used, it is recommended chosing of a "multiproperty" strip that includes fields for haematuria, proteinuria, glucose and ketones, leukocytes esterase (indicating the presence of leukocytes in the urine) and nitrite tests (suggesting bacteriuria). (***Unanimous agreement***)

2. SUGGESTED RESEARCH AREAS

Determine the role of urinalysis as a screening test in various incontinent populations.

Determine the prognostic significance of urinalysis in urinary incontinence

II. CHEMICAL TESTS

The prevalence of renal damage or of biochemical abnormalities in the general population of patients with urinary incontinence is very low, but there are subgroups of patients where the prevalence can be higher (e.g., neurogenic incontinence, overflow incontinence).

The routine use of a battery of common chemical and/or haematological tests in patients with urinary incontinence appears to be a prudent rule of good clinical practice in the following situations:

a) chronic retention with incontinence

b) neurogenic LUT dysfunction

c) when surgery is contemplated

d) when there is a clinical suspicion.

The cost of performing a single test can be similar to the cost of a battery of tests.

Special tests such as ADH and measurement of atrial natriuretic polypeptide have proven useful in research of enuresis in childhood and nocturia in the elderly [1,2]. Changes in the circadian rhythm of these, and probably also other hormones regulating the renal excretion of water, will in the future contribute to a better understanding of pathophysiology. Synthetic ADH-analogues have already come into clinical use for the treatment of nocturnal enuresis. However, the clinical value of these specific tests remains to be established.

Sex hormones exert physiological effects on the female urinary tract, with estrogens having an additional influence on the structures of the pelvic floor [3]. High affinity estrogen receptors have been identified in the bladder, trigone, urethra and pubococcigeus muscle of women. Oestrogen pretreatment enhances the contractile response of animal detrusor muscle to alpha-adrenoceptor agonists, cholinomimetics and prostaglandins, as well as enhances the contractile response to alpha-agonists in the urethra.

The dependence on oestrogens of the tissues of the lower urinary tract contributes to increased urinary problems in postmenopausal women.

Usually oestrogen deficiency is clinically evaluated on the basis of the presence of atrophic urethritis and vaginitis. Estrogen status can be ascertained via plasma estradiol and estrone levels, as well as from parabasal and superficial cell counts from both the urethra and the vagina [4].

Recently, Ayshek et al [5] developed a method of determining the ability of plasma to inhibit purified elastase activity and showed that the plasma from 30 women with urinary stress incontinence had a reduced capacity to inhibit the activity of purified elastase compared to 30 age-matched control women. The loss of inhibition of elastase activity might result in increased elastin degradation in connective tissues supporting the bladder and the urethra and contribute to the development of stress incontinence.

1. Recommendation

Standard chemical tests for renal function are recommended in patients with urinary incontinence and a high probability of renal damage [***Intermediate Level Evidence- Unanimous agreement***].

2. Suggested research areas

search for plasma markers of defective pelvic floor connective tissue

III. TISSUE ANALYSIS

Microscopic, morphometric, histochemical and ultrastructural analysis of specimens from various sites (skin, vagina, levator ani and detrusor) of patients with urinary incontinence is an exciting research line. This was applied mainly but not only to female urinary incontinence with or without genital prolapse.

A defect in connective tissue can be the cause of female stress urinary incontinence, possibly associated with defective support due to concomitant genital prolapse.

Brincat et al [1-3] intensively studied skin collagen in relation to menopause, concluding that skin collagen is influenced by sex hormones status and declines after menopause. Skin collagen content from skin biopsy specimens was found to be significantly greater (48%, $p < 0.01$) in a group of postmenopausal women (29) treated with sex hormone implants, compared to an untreated group of women (26) who were matched for age.

Versi et al [4] hypothesized skin collagen as a model of urethral collagen and concluded that collagen may be the pivot through which oestrogens have their beneficial effect on sphincteric function.

Norton et al [5,6] showed that collagen synthesis is altered in recurrent inguinal haernia and in recurrent genital prolapse. They reported also that joint hypermobility, a clinical marker for abnormal collagen, was prevalent in women with genital prolapse but not in women with stress incontinence. They were not able to show differences in collagen synthesis in women with stress incontinence.

Keane et al [7] compared the collagen content, the type I:III collagen ratio and the collagen cross-link content in specimens obtained from periurethral vaginal biopsies in 36 premenopausal nulliparous women with urodynamically proven genuine stress incontinence, with 25 continent controls. The nulliparous women with genuine stress incontinence had significantly less collagen in their tissues ($P < 0.0001$) compared with the continent controls. There was also a decreased ratio of type I to type III collagen ($P= 0.0008$) and a decrease of the collagen cross-link content.

The concept at the basis of this research line is that there is an active and dynamic ongoing process of turnover and remodeling of the pelvic connective tissue which can explain acquired or congenital, general or sectorial disorders.

Decreased innervation in female stress incontinence is another point of interest. Gilpin, Gosling et al [8] compared histological and histochemical analysis of biopsy samples of pubococcygeus muscle obtained from asymptomatic women and from women with stress urinary incontinence. In incontinent women there was a significant increase in the number of muscle fibres and changes in the diameter of type I (slow-twitch) and type II (fast twitch) fibres showing pathological damage, attributable to partial denervation of the pelvic floor.

Hanzal et al [9] claimed prognostic importance for the outcome of patients with genuine stress incontinence undergoing anteroposterior vaginal repair depending on the presence of striated muscle tissue in biopsies from pubococcygeal muscle. The absence of striated muscle tissue in 19 patients was associated with poor clinical and urodynamic outcome in comparison with 11 patients with the presence of striated muscle tissue in the specimen.

Helt et al [10] found no evidence of denervation or reinnervation in levator ani muscle biopsies from incontinent and/or prolapse patients compared to asymptomatic women.

Falconer et al [11] studied transvaginal biopsies near the external meatus from 11 stress incontinent women of fertile age and from 10 comparable controls, processed for indirect immunochemistry using protein b gene product 9.5 (PGP 9.5) as a general neuronal marker. Nerve fibre profiles/mm of projected epithelial area were significantly lower in the incontinent group, suggesting decreased innervation.

Elbadawi et al [12-14] in an extensive study program showed distinctive ultrastructural features of muscles, nerves and interstitium of the detrusor in various urodynamic conditions (detrusor overactivity, impaired contractility, outflow obstruction, aging bladder). These findings need to be reproduced by different groups.

In conclusion, tissue analysis in urinary incontinence is an interesting and promising research line. There is a need for further studies on pelvic floor components (connective and muscular tissue) and on detrusor.

G. CONCLUSIONS

Only a few of the imaging techniques and other investigations we considered have been properly evaluated in the literature with respect to reproducibility, specificity, sensitivity and predictive value in connection with the diagnosis and the management of urinary incontinence.

The routine clinical use of imaging techniques and other investigations is often based on expert opinion, common sense or local expertise and availability, rather than on evidence based clinical research.

The assessment methods we considered can be subdivided into safety tests, tests with specific indications and investigational tests.

Safety tests are indicated in all patients complaining of urinary incontinence. This refers to urinalysis and residual urine evaluation. While for urinalysis there is easy agreement, the role of PVR measurement as a safety test, proposed at the level of basic assessment in many algorithms, needs to be confirmed in terms of validity and cost effectiveness by means of prospective studies.

Tests with specific and selected indications follow.

Upper urinary tract imaging (as well as renal function assessment) may be indicated in cases of neurogenic urinary incontinence with risk of renal damage, chronic retention with incontinence, incontinence associated with severe genitourinary prolapse and suspicion of extraurethral incontinence.

The role of imaging techniques in the study of female urinary incontinence and of the pelvic floor is not yet established.

Cystourethrography has been well studied in terms of intra- and inter-observer variability, but cannot be recommended for the diagnosis or classification of urinary incontinence, while it is a reasonable option in the preoperative evaluation of complicated and/or recurrent cases.

Pelvic floor ultrasound is widely used in some countries. This technique is in rapid and continuous technologic and methodologic evolution. Pelvic floor ultrasound is very promising, but it should still be considered investigational, although standardisation is already in process.

In female urinary incontinence, as well as in neurogenic and postprostatectomy incontinence, the gold standard remains the simultaneous performance of imaging and urodynamics (videourodynamics). Some morphological findings, such as, open bladder neck and proximal urethra at rest, bladder wall thickness, diverticula and pseudodiverticula, membranous urethral narrowing, can have clinical and diagnostic relevance.

Lumbosacral spine X-rays have specific indications in children with suspect neurologic incontinence without gluteo-sacral stigmata.

Imaging of the CNS should be considered when a neurologic disorder is suspected on the basis of clinical, imaging and neurophysiological findings.

Urethrocystoscopy is indicated in cases of incontinence with microscopic haematuria, in the evaluation of recurrent or iatrogenic cases, in the evaluation of vesico-vaginal fistula and extra-urethral urinary incontinence.

The following tests were considered ***investigational***: ultrasound and MRI of the pelvic floor, MRI and functional neuro-imaging, and tissue analysis.

MRI of the female pelvic floor is to be considered the most promising research tool with potential future clinical applications, due to the tremendous amount of simultaneous information it can provide. Its main present limitation is that MRI is not available everywhere and cost effectiveness studies are needed.

Functional neuroimaging is going to provide new insight on functional anatomy of CNS related to vesicourethral function and dysfunction.

Many of these tests promise improvemements in our knowledge of pathophysiology of urinary incontinence and possibly better management.

The content of the draft inevitably reflects the composition of the Committee. The members are all clinicians, users of imaging techniques, without being necessarily experts of technology. Specific experts in imaging methods, like MRI and functional imaging of the CNS should be involved in the future.

The main goal of clinical research in the field we covered remains the prospective evaluation of accuracy, efficacy and cost-effectiveness of imaging techniques and other investigations and the validation of their role in the assessment flow charts of various types of urinary incontinence.

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B. LOWER URINARY TRACT (LUT) IMAGING

B-I. IMAGING IN FEMALE URINARY INCONTINENCE AND PELVIC FLOOR DYSFUNCTION

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II. ULTRASOUND OF THE LOWER URINARY TRACT AND PELVIC FLOOR IN FEMALE URINARY INCONTINENCE

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