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Original Article

Anatomical Assessment of the Bladder Outlet and Proximal Urethra using Ultrasound and Videocystourethrography

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Abstract: In a prospective blinded comparative clinical study 125 women underwent videocystourethrography and cystometry as well as transperineal ultrasound as part of their diagnostic work-up for urinary incontinence or after incontinence-correcting surgery. Comparisons between ultrasound and X-ray imaging were carried out on 117 women for whom complete data sets were available. Mean bladder neck descent was significantly greater with ultrasound compared to VCU (US: 2.1 ± 1.2 cm vs. VCU: 1.8 ± 0.9; $P = 0.003$). Rotation of the proximal urethra was not always seen on X-ray, but when it was (44 patients) there was good correlation with US (US rotation 55 ± 27° vs. VCU rotation 55° ± 29). There was also good agreement between both tests regarding visualization of funneling or opening of the proximal urethra, with both tests showing equivalent results in 95 out of 117 patients (Cohen's κ 0.58). On comparing extensive funneling to the midurethra on US with frank leakage on VCU the methods were in agreement for 90 out of 117 patients (κ 0.54). Overall a good correlation between ultrasound and radiological findings was observed. Both methods allow anatomic assessment of the bladder neck and have different strengths and weaknesses. Ultrasound imaging may be preferable as it is chaper, requires less technological back-up and avoids the risks of radiation exposure and allergic reactions to contrast medium.

Keywords: Cystourethrography; Female urinary incontinence; Perineal ultrasound; Ultrasound; Urodynamics

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Introduction

Over the last 10 years there has been considerable interest in the use of ultrasound for the evaluation of genuine stress incontinence. Transvaginal [1–4], transrectal [5–7] and transperineal ultrasound [8–14] has been used to assess the bladder neck and urethra. Recently an attempt has been made to standardize the interpretation of ultrasound data [15]. However, there still is little published concerning a direct comparison of ultrasound results with the 'gold standard' of videocystourethrography (VCU). The aim of this study was therefore to compare qualitative and quantitative anatomical information obtained by transperineal ultrasound with the findings of contrast videocystourethrography.

Patients and Methods

Between March 1995 and June 1996, 125 women underwent VCU and transperineal ultrasound, either as part of the investigation for urinary incontinence or as follow-up after incontinence-correcting surgery at Dunedin Hospital, Dunedin, New Zealand. There was an initial pilot study consisting of 46 patients and then a subsequent prospective study of 79 patients. In the pilot study ultrasound imaging was carried out in the supine position, with variable bladder filling and without pressure lines. This was then compared with the radiological examination, both in the supine and the erect positions, with a 15° oblique view at maximum bladder capacity with pressure lines in situ. In the prospective study, ultrasound was performed at the same time as the VCU and both tests were carried out with pressure lines in situ at identical (maximum) bladder

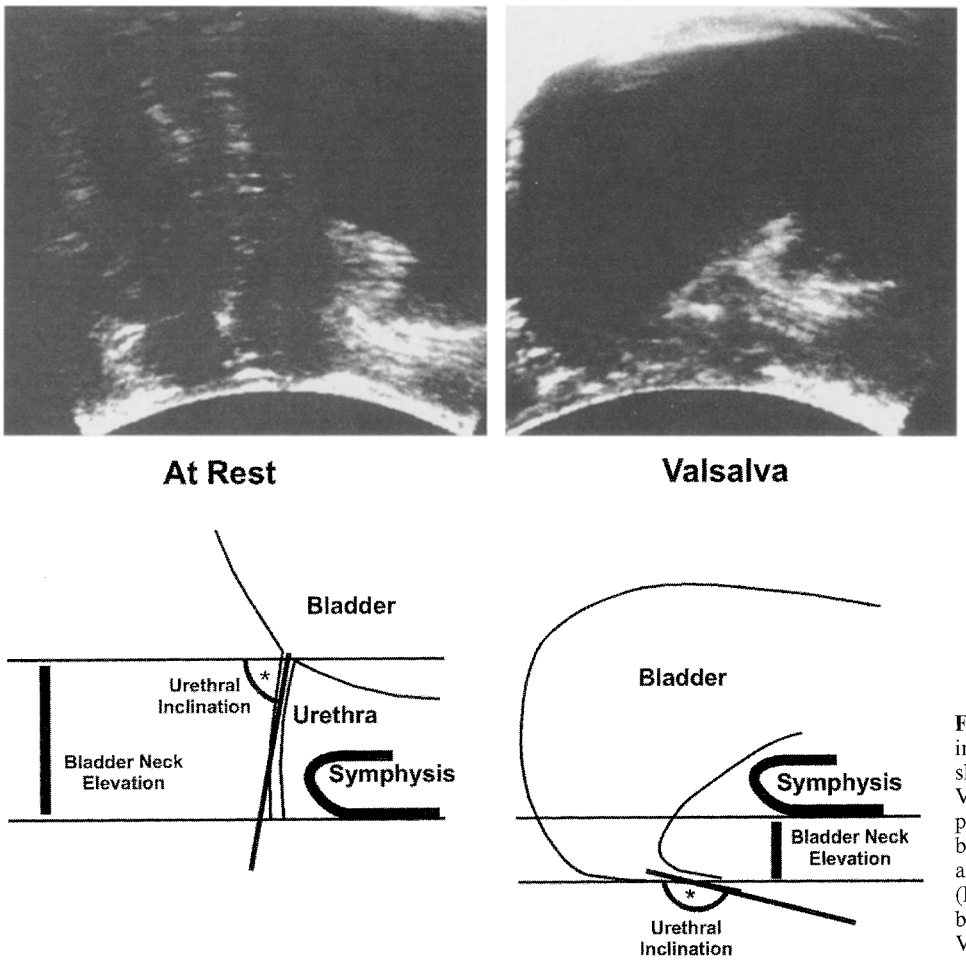

Fig. 1. Transperineal ultrasound images (above) with accompanying sketch (below), at rest and on Valsalva maneuver. Rotation of the proximal urethra is the difference between urethral inclination at rest and Valsalva; bladder neck descent (BND) is the difference between the bladder neck elevation at rest and Valsalva.

capacities in the supine position. Radiological screening also was performed in the erect position as part of the routine VCU investigation.

Video pressure–flow cystourethrography was carried out as described previously [16] using urografin contrast medium. Ultrasound imaging was carried out using a curved linear array ultrasound scanner (Sloka SSD 500) with a 3.5 MHz transducer which was placed on the perineum in a sagittal orientation to obtain views of the bladder, bladder neck, urethra and symphysis pubis. On Valsalva maneuver, downward displacement but no angling of the probe in the anteroposterior direction was allowed.

Bladder neck descent (BND) and rotation of the proximal urethra were recorded using both ultrasound and VCU. The former was analyzed by drawing parallel lines through the inferior margin of the symphysis pubis and the internal meatus of the urethra, perpendicular to the incident ultrasound beam, and measuring the distance between these lines. The interobserver agreement of a similar ultrasound measuring technique has recently been described as good [17]. On fluoroscopy a radio-opaque ruler placed behind the patient was used to estimate descent.

Simple funneling or opening of the proximal urethra on Valsalva was recorded with both methods. Extensive funneling to the midurethra on ultrasound was held to correspond to frank leakage of contrast medium on fluoroscopy. Valsalva maneuvers were carried out in an identical manner with both VCU and ultrasound, but pressure standardization on Valsalva was not undertaken. Both tests were recorded separately on video tape or as still and assessed blindly at a later date (VCU by PDW, ultrasound by HPD).

Statistical Analysis

As the results were similar with both the pilot and the prospective study, patients from both studies were combined. For continuous data Student's t-test was used; for categorical data the χ^2 test (Fisher's exact test) and Cohen's κ. To measure agreement between continuous variables, intraclass correlation coefficients were calculated.

Results

Of 125 patients seen, a comparison of tapes and measurements was possible in 117 cases. Five patients did not have contrast imaging because of iodine allergy, two tape recordings were of poor quality and 1 patient

Table 1. Patient characteristics (n = 117)

Predominant symptom	
Stress incontinence	44
Urge incontinence	18
Mixed	31
Voiding difficulty	2
Unclear	3
None	19
Previous surgery	
Laparoscopic colposuspension	29
Burch colposuspension	6
Anterior colporrhaphy	4
Macroplastique	2

Table 2. Comparison of ultrasound and VCU for bladder neck descent (n = 117) and rotation of the proximal urethra (n = 44)

	Ultrasound (mean ± SD)	VCU (mean ± SD)	P
Bladder neck descent (cm)	2.1 (1.2)	1.8 (0.9)	0.003
Rotation of prox. urethra (°)	55 (27)	55 (29)	n.s.

was unidentifiable. Table 1 gives the characteristics of the patients included in the study. The average age was 51.4 years (range 14–84); 93 patients were seen for investigation of incontinence, 41 after incontinence-correcting surgery.

The results of bladder neck descent and rotation are summarized in Table 2. Mean bladder neck descent was significantly greater with ultrasound compared to VCU (2.1 ± 1.2 cm vs. 1.8 ± 0.9 cm; P = 0.003). Rotation of the proximal urethra was not always seen on X-ray, but when it was (44 patients) there was good correlation between X-ray and US.

Table 3. Correlation between the finding of funneling or opening of the bladder neck on ultrasound and radiological investigation (n = 117). Cohen's κ 0.58

Opening of bladder neck	VCU pos	VSU neg
US pos	66	9
US neg	13	29

Table 4. Correlation between the finding of extensive funneling or opening to the midurethra of the bladder neck on ultrasound and frank leakage on VCU (n = 117). Cohen's κ 0.54

VCU: leakage	pos	neg
US ext. funneling	43	17
US no ext. funneling	10	47

A scattergram of BND measurements is shown in Fig. 2, illustrating good correlation between the two tests (intraclass correlation coefficient 0.76). Taking a cutoff for normal bladder neck descent as less than 1.5 cm (our current clinical practice), both tests were in agreement in 104 out of 117 cases (κ 0.76).

Simple funneling or opening of the bladder neck was seen in 75 out of 117 patients on ultrasound and 79 out of 117 on VCU. In 95 out of 117 cases both methods were in agreement (κ 0.58, Table 3).

The results for extensive funneling to the midurethra on ultrasound, compared to frank leakage on VCU, are given in Table 4. Both tests yielded positive results in 43 patients and negative results in 47. In 27 cases there were discrepancies (κ 0.54).

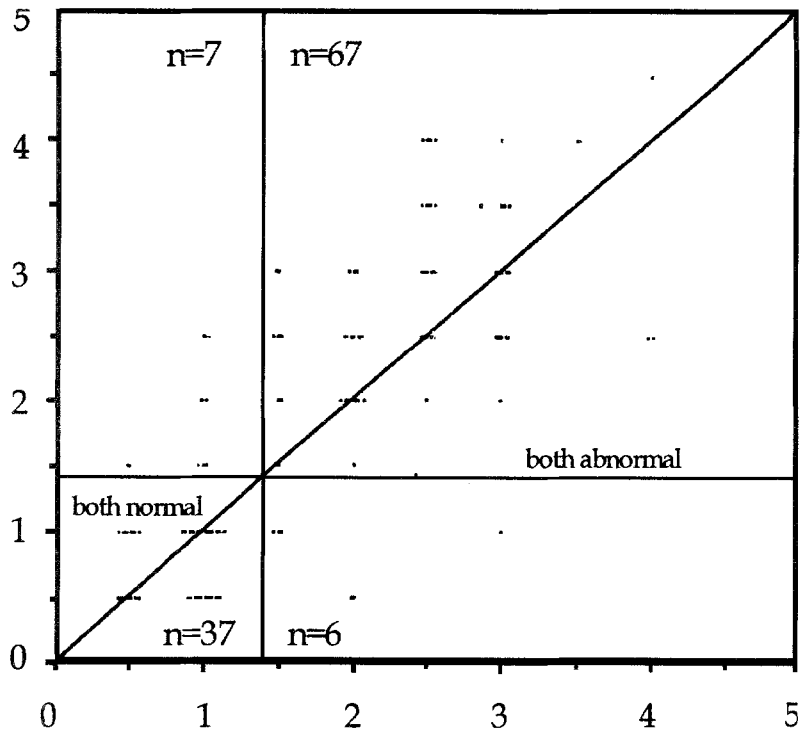

Fig. 2. Scattergram representing the values obtained for bladder neck descent by ultrasound and VCU imaging (n = 117). Intraclass correlation coefficient = 0.76.

Discussion

The main purpose of imaging of the lower urinary tract in the investigation of a patient with stress incontinence is first, to confirm the diagnosis of genuine stress incontinence (funneling or opening of the bladder neck ± leakage of urine or contrast medium in the absence of a detrusor contraction), and secondly to ascertain the cause. Commonly genuine stress incontinence is due to urethral hypermobility (significant displacement of the urethra and bladder neck when intra-abdominal pressure is raised) or intrinsic urethral sphincter deficiency. At present, video pressure–flow cystourethrography (VCU) is the gold standard of urodynamic investigation and can provide information on all of the above. However, this test is expensive, has the inherent problems of radiation hazard to patients and staff, and also carries the risk of allergic reactions to contrast media. Ultrasound can give similar information, but to date there are few published data directly comparing ultrasound results with VCU findings.

The results of this comparative study of transperineal ultrasound with VCU have, on the whole, shown good correlation between the two tests. Bladder neck descent was easily documented with both methods, with ultrasound yielding higher measurements. Estimates of rotation did not differ significantly and simple opening/funneling was also observed with both methods, though more easily with VCU, and there was good agreement between the methods. Cough leakage on VCU was compared to extensive funneling to the midurethra on ultrasound, and again both parameters correlated relatively well.

The observed discrepancies may be due to inter-observer variability, as the results of the two methods were evaluated by two operators. Other confounding factors may be the position of the patient, the variable strength of Valsalva maneuvers, and better relaxation of the patient on ultrasound imaging, as suggested by Schaer [18]. The strength of Valsalva maneuvers was recorded but the prevalence of artifacts made the data difficult to analyze. We suspect that as more attempts were undertaken on ultrasound imaging, the maximal intra-abdominal pressure generated may have been higher on average. This may influence bladder neck descent as well as rotation and funneling/opening of the proximal urethra.

As this was a pragmatic trial comparing the information from two tests as they are used in clinical practice, we did not look at the effect of posture. Our observations suggest that simple or extensive funneling on ultrasound is more easily observed in the erect position, as it is on radiological imaging. Another way of improving the ultrasound visualization of urine leakage may be the use of contrast media [19]. The authors have been involved in the development of an echogenic suspension which could be used as a contrast medium for ultrasound imaging in incontinence diagnostics [20].

A number of authors have compared transrectal and transvaginal ultrasound findings with urodynamic testing and X-ray imaging [4,6,7], but such findings are very difficult to compare with the data presented here. There are also a number of studies using transperineal ultrasound [11,13,18,23–25], but measured parameters and classifications vary widely.

Two similar comparative studies using transperineal ultrasound have been reported recently [18,25]. The conclusion of Schaer et al. was that only minor differences were detectable between imaging in the supine and the erect positions, and that ultrasound seemed to better reflect the mobility of the bladder neck. Our data for bladder neck descent supports this assumption. Voigt et al. [25] concluded that 'both techniques are comparable methods giving similar results' regarding the anatomy of the bladder outlet.

Overall, the above findings suggest that ultrasound is capable of documenting the anatomy of the bladder neck and proximal urethra and the changes associated with genuine stress incontinence. This conclusion is supported by a review of the available literature, even if the methods and parameters used vary widely and comparisons between different authors are almost impossible. A standardization of technique and reporting has recently been attempted [15]. Our study was undertaken before the publication of this proposal, but appears compatible with its recommendations.

As regards the choice of technique and the parameters to be documented, transperineal ultrasound is now available to many gynecologists. Standard equipment in use in obstetrics and gynecology can be employed without modification. Its non-invasive nature implies better patient compliance, and distortion of the lower urinary tract is unlikely. As hypermobility of the bladder neck and opening of the proximal urethra are the two most commonly observed signs of genuine stress incontinence on imaging, one would suggest that quantitative (bladder neck descent, rotation of proximal urethra and retrovesical angle) as well as qualitative parameters (simple or extensive funneling/opening of the bladder neck) be recorded both at rest and on Valsalva maneuver.

Conclusion

Perineal ultrasound is a useful means of documenting the anatomy of the bladder neck and proximal urethra and the anatomical changes associated with genuine stress incontinence. The measurements obtained by ultrasound correlate well with X-ray findings, and all relevant parameters can be assessed using transperineal ultrasound. Potential benefits of the new technique in the setting of incontinence diagnostics include increased patient compliance, decreased cost and staff requirements, no radiation hazard to patients and staff, and arguably the chance to obtain quantitative anatomical information of higher quality.

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EDITORIAL COMMENT: The present study underlines the increasing clinical value of sonographic urethrocystography and supports existing publications that ultrasound complements urogynecologic assessment. However, further study is necessary to concentrate on entities such as urethral hypermobility or intrinsic sphincter incompetence. There is at present, no real definition based on data from imaging analysis.