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URODYNAMIC EVALUATION OF VOIDING FUNCTION IN FEMALES WITH STRESS URINARY INCONTINENCE

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Objective The evaluation of voiding function in females with lower urinary tract symptoms (LUTS) with special emphasis on the evaluation of storage function and the state of continence.

Patients and Methods 176 patients were investigated for urinary incontinence-related problems at the Unit for Neuro-Urology and Urodynamics of the Department of Urology, University Medical Center Nijmegen (The Netherlands). The patients were classified into two groups according to their symptoms and urodynamic studies. Group I consisted of 103 patients with stress urinary incontinence (SUI), while Group II included 73 patients with other forms of urinary incontinence or no urodynamic abnormalities at all. All patients were subjected to urodynamic investigations including uroflowmetry, static and dynamic urethral pressure profiles, filling cystometry and pressure-flow studies.

Results It was noted that the bladder capacity as well as the average and maximum flow rates tended to be higher among patients with SUI. Some insignificant increase in outlet obstruction, as assessed by the Lin PURR nomogram was noticed. Detrusor contractility was only found to be significantly reduced in patients with SUI when the total Watts factor was compared in both groups.

Conclusion When comparing both groups, significant differences were found in the filling cystometry as well as in the urethral pressure profile variables. Some differences were also detected with regard to pressure-flow studies and detrusor contractility during voiding.

Key Words voiding function, urinary tract symptoms, urodynamics

INTRODUCTION

The aetiology of genuine stress urinary incontinence (SUI) exhibits a dual mechanism, either caused by descent of the bladder neck and base (SUI types I and II) or by insufficiency of the intrinsic sphincter mechanism (SUI type III)[1]. Descent and funnelling would also carry the risk of significantly altering the net outlet resistance[2]. For these reasons it can be assumed that in stress urinary incontinence a reduced outlet resistance might be found on pressure-flow analysis. This decrease of the outlet resistance will subsequently negatively affect the detrusor work, assuming that $R = Pdet/(Qmax)^2$, where R is the resistance factor, Pdet is the detrusor pressure and Qmax is the maximum flow rate[3]. This study aims at verifying these theoretical assumptions through objectively assessing and comparing a group of patients with genuine SUI with a second group without such a condition.

PATIENTS AND METHODS

For this study, the files of 176 consecutive patients who had been referred to the urodynamic unit for further evaluation were reviewed: 70 patients were referred by gynecologists, 66 were referred by urologists and 39 by other specialists (e.g. neurologists, psychiatrists). All patients underwent the following investigations: uroflowmetry, static and dynamic urethral pressure profile measurement, medium fill water cystometry and pressure-flow analysis. In all investigations a 7 Fr. micro tip transducer catheter [MTC^R, Drager, Best, The

Table 1: Filling Cystometry Parameters

	Bladder Vol. 1st Desire (ml)	Pressure 1st Desire (cm H2O)	Bladder Vol. Strong Desire (ml)	Pressure Strong Desire (cm H2O)	Bladder Vol. End-Filling (ml)	Pressure End-Filling (cm H2O)	Compliance (ml/cm H2O)
Group I (n=103)	168 ± 123	20 ± 11	403 ± 185	24 ± 10	479 ± 182	26 ± 12	55 ± 38
Group II (n=73)	127 ± 95	19 ± 10	334 ± 171	24 ± 12	405 ± 191	26 ± 12	50 ± 45
P-value	0.03*	0.49	0.02*	0.56	0.02*	0.69	0.5

* Significant p value at 0.05 level using 2-tail t-test

Table 2: Mean Free Flow Parameters

	Average Flow Rate (Qave) (ml/s)	Maximum Flow Rate (Qmax) (ml/s)	Flow Time (sec)
Group I (n=103)	11 ± 5	20 ± 9	41 ± 23
Group II (n=73)	8 ± 4	18 ± 8	46 ± 24
P value	0.0001*	0.033*	0.155

* Significant p value at 0.05 level, using 2-tail t-test

Netherlands] was used for recording the intravesical, urethral and intra-abdominal (rectal) pressure, with a filling rate of 50 ml/min. Uroflowmetry was done using an automatic rotating disk flowmeter (Urodyn 1000 ^{R}, Dantec, Denmark). A urethral pressure profile (UPP) was carried out in the supine position, while filling and voiding cystometry were done with the patients in the sitting position. For uroflowmetry, the average (Qave) and maximum (Qmax) flow rates were recorded as well as the voiding time. The UPP parameters included were maximum urethral closure pressure, and functional urethral length.

The filling cystometry was studied in terms of bladder volume and pressure at first desire, at strong desire and the end of the filling phase. Compliance was defined as the rate of change of bladder volume in response to a change in bladder pressure (Δ V/ Δ P)[4]. The maximum detrusor pressure during voiding (Max pdet) was estimated. In the evaluation of micturition, different parameters were used including: Schäfer's nomogram[5], which depends on the concept of a linearized PURR (Lin. PURR). Originally, PURR (passive urethral resistance relations) is a quadratic model that is fitted to the lowermost part of the pressure flow plot, passing with the point of Pdet Qmax (detrusor pressure at the maximum flow point)[6]. The PURR curve denotes obstruction by virtue of its steepness, so that a theoretical area of urethral cross section could be computed for a certain PURR[7]. Yet, when Lin. PURR is used, a seven-bands nomogram could be obtained. Plotting of the pressure and the flow according to the method described by Schäfer was selected[6] when the pressure flow study was assessed.

Another computational parameter, the urethral resistance factor (URA), was used in the analysis of the pressure flow study. It is derived from a statistical quadratic model utilizing two parameters of the pressure flow study: Pdet Qmax and steepness of the slope of the pressure flow curve[8]. URA is a pressure value representing the minimum detrusor opening pressure for a known Pdet Qmax. It was elicit-

Table 3: Mean Urethral Pressure Profile Parameters

	Functional Urethral Length (cm)	Max. Urethral Closure Pressure (cm H2O)
Group I (n=103)	2.6 ± 0.7	46 ± 21
Group II (n=73)	2.8 ± 0.8	57 ± 28
P value	0.19	0.004*

* Significant p at 0.05 level using 2-tail t-test

ed via statistical analysis of a large number of PURR for a group of patients with senile prostatic obstruction, with an approximate cut-off value of 15 cmH_2O[9].

When assessing the detrusor contractility, the Watts factor (WF) was chosen to address this issue. WF represents the power of the bladder during shortening and may be calculated from the detrusor voiding pressure and the intravesical volume[10]. Griffiths et al.[11] have calculated WF max in normal females to be 10-20 $Watts/m^2$. All units of measurement and methods conform to those specified by the International Continence Society (ICS)[12].

The program used for urodynamic testing was developed by the biomedical engineering department (UIC/BME, Urology Department, University Medical Center Nijmegen). All investigations were synchronously displayed on a colour monitor and recorded on floppy diskettes at a speed of 8 Hz/s.

The patients were divided in two groups: Group I with the diagnosis of stress urinary incontinence (SUI) included 103 patients. SUI was diagnosed on clinical grounds (history and positive stress test) and confirmed by urodynamics. Group II included 73 patients with other diagnoses. Eleven patients in Group II had urge incontinence, while the remaining patients had symptoms suggestive of voiding dysfunction and / or neuropathic bladder disorders or had normal urodynamic investigations. Only 94 patients in Group I and 66 patients in Group II completed the pressure flow studies and were valid for a comparison of Schäfer's grade, URA, maximum detrusor voiding pressure and Watts Factor.

The analysis of the stored data was carried out using the aforementioned program with manual correction of the pressure-flow parameters and automatically selected marks (e.g. beginning and end of the urethral pressure profile, beginning and end of voiding). The statistical analysis was done using the SPSS/PC software. The two-tail T-test was used to determine the statistical significance of differences for all parameters.

RESULTS

The mean age of the patients was 56 ± 13.5 years (range: 31- 83 years). The mean age of the 103 patients in Group I was 55 years and for the 72 patients in Group II it was 57 years. Out of the 103 patients with stress incontinence, 10 patients had had previous incontinence pelvic surgery.

The cystometric parameters for both groups are illustrated in Table 1. The difference between the two groups was significant with respect to the bladder volume at first desire, at strong desire and at cystometric (end fill) capacity.

Patients with SUI had significantly higher average (Qave) and maximum flow (Qmax) rates. Table 2 demonstrates the difference between the two groups as regards uroflowmetry.

Table 3 includes a listing of the urethral pressure profile (UPP) differences between Groups I and II. As expected, the mean maximum urethral closure pressure (MUCP) showed a statistically significant difference. Mean MUCP in women with SUI (Group I) was 46 ± 2 cmH_2O, while in women without SUI (Group II) the mean value was 57 ± 3 (p= 0.004). However, the functional urethral length did not significantly differ between the two groups.

The mean maximum detrusor pressure (during voiding) among women with SUI (Group I) was 23 cm H_2O while among women without SUI (Group II) it was 26 cmH_2O (p=0.35). At detrusor opening pressure (p det.open) the difference between the two groups was also insignificant (8.8 vs. 13 for Groups I and II, respectively, p=0.09). The difference was not significant when comparing the two groups as regards Schäfer's Lin PURR grade of obstruction (p=0.25). Nevertheless,

Table 4: Voiding Cystometry Parameters

	Max. Detrusor Pressure (cm H2O)	Detrusor Opening Pressure (cm H2O)	URA♦ (cm H2O)	Schäfer's Grade♦♦
Group I (n=94)	23 ± 15	8.8 ± 14	10 ± 6	0.3 ± 0.6
Group II (n=66)	26 ± 18	13 ± 16	12 ± 7	0.4 ± 0.7
P value	0.35	0.09	0.026*	0.25

* Significant p at 0.05 level, using 2-tail t-test
♦ URA = urethral resistance factor
♦♦ Schäfer's grade: the grade of Lin-PURR according to Schäfer's nomogram

Table 5: Contractility Parameters (Watts Factor – WF)

	WF Maximum (W/m^2)	WF Volume (ml)	WF Total (W/m^2)
Group I (n=94)	12.5 ± 8	160 ± 169	235 ± 159
Group II (n=66)	12 ± 6	126 ± 197	314 ± 230
P value	0.77	0.64	0.017*

* Significant p at 0.05 level using 2-tail t-test

URA exhibited a statistically significant difference when the women with SUI were compared to the women without SUI (p=0.026) (Table 4)

The energy consumed by the detrusor during voiding was assessed by estimating the "Watts Factor". Overall, in our patient cohort, the women with SUI voided with less energy expenditure than those without SUI. The WF total for Group I was 235 ± 159 W/m^2, while for Group 2 it was 314 ± 230 W/m^2.

DISCUSSION

The application of pressure flow studies in females has been regarded as a controversial issue. Massey and Abrams have used the pressure flow nomogram to assess the incidence of significant bladder outlet obstruction (BOO) among women[13]. In our study, the Lin-PURR nomogram with its seven grades was used, as it was found to be more decisive in the quantification of the degree of obstruction, by virtue of its larger number of grades and smaller area of equivocal relation[14]. In addition, Walker et al.[15] have proved that the method of Lin-PURR, as described by Schäfer, is more sensitive than the Abrams-Griffiths nomogram to changes in the pressure flow relation following urethral instrumentation.

Our results have demonstrated that in women with SUI the bladder capacity tends to be larger than in patients without SUI. The study of Qave and Qmax in uroflowmetry revealed a statistically significant difference between the two groups. This is appreciable in the light of the tendency of the patients in Group II to have a higher degree of obstruction at the assessment of pressure flow analysis. Table 4 demonstrates that there are clear differences regarding maximum detrusor voiding pressure, detrusor opening pressure and Schäfer's grade. However, these differences did not reach a level of statistical significance. Only the urethral resistance factor (URA) displayed a significant difference between the two groups.

Wagg et al.[16] demonstrated that p det.open was significantly lower in women with SUI than in women without such condition. In this current study, we failed to reproduce this observation. Comparing detrusor contractility during voiding, using the Watts factor, WF maximum as well as WF volume showed no statistically significant difference between the two groups. Nevertheless, WF total was significantly higher in Group II (Table 5). This might support the notion that Group II had a more marked degree of obstruction shown by a higher URA and utilized more energy proved by a higher WF total.

As for the urethral pressure profiles, two parameters were used, namely the functional urethral length and the maximum urethral closure pressure. A statistically significant difference existed between the two groups concerning MUCP, a finding that goes along with the work of others on female SUI, where a significant decrease of the urethral closure pressure was a salient feature of this pathology[17].

In conclusion, this study has demonstrated that the voiding pressure in women with SUI is not different from women without this disease entity. In our patient cohort a better free flow pattern could be attributed to a larger bladder capacity among patients with SUI or to the presence of an insignificant difference in the degree of bladder outlet obstruction, as assessed by Schäfer's nomogram. Patients without SUI are characterized by a higher degree of bladder outlet obstruction. The overall working load during voiding seems less heavy in women with SUI than in women without.

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RESUME

Evaluation Urodynamique chez des Femmes Présentant une Incontinence Urinaire d'Effort

Objectif : Evaluation des paramètres mictionnels chez des femmes présentant des symptômes des voies urinaires inférieures (LUTS) avec un intérêt particulier sur l'évaluation de la fonction de remplissage et l'état de continence. **Matériel et Méthode** : 176 patientes ont été investiguées pour des problèmes d'incontinence dans l'unité de Neurourologie et d'Urodynamique du département d'Urologie du Centre Médical Universitaire de Nijmegen (Pays-Bas). Les patientes ont été classifiées en deux

groupes selon leurs symptômes et les résultats urodynamiques. Le groupe I consiste en 103 patientes présentant de l'incontinence urinaire d'effort (SUI) et le groupe II comprenait 73 patientes présentant d'autres types d'incontinence urinaire ou l'absence de toutes anomalies urodynamiques. Toutes les patientes ont subi une évaluation urodynamique complète comprenant une débitmétrie, un profil de pression urétrale statique et dynamique, une cystométrie de remplissage et une étude pression-débit. **Résultats** : Il a été observé une plus grande capacité vésicale et un débit maximum plus élevé dans le groupe de patientes présentant une incontinence urinaire d'effort (SUI - groupe I). Un degré peu significatif d'augmentation d'obstruction à la vidange vésicale évaluée par le Lin PURR nomogramme a été observé. La contractilité du detrusor était uniquement réduite chez les patientes avec une incontinence urinaire de stress (SUI) lorsque l'ensemble des facteurs Watts a été comparé dans les deux groupes. **Conclusion** : La comparaison des deux groupes de patientes montre des différences significatives dans la cystométrie de remplissage ainsi que dans le profil de pression urétrale. Certaines différences ont également été observées lors des études de pression-débit et de la contractilité du detrusor lors de la miction.

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