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DETRUSOR PRESSURE UROFLOWMETRY STUDIES IN WOMEN: EFFECT OF A 7FR TRANSURETHRAL CATHETER

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ABSTRACT

Purpose: We evaluated whether a 7Fr transurethral catheter affects urinary flow in women undergoing pressure flow studies for voiding symptoms.

Materials and Methods: We reviewed a urodynamic database of 600 consecutive women referred for the evaluation of voiding symptoms. Before urodynamics all patients voided privately using a standard toilet and free flow was recorded. Urodynamics were performed using a 7Fr double lumen transurethral catheter. At functional bladder capacity patients were asked to void in the sitting position and pressure flow studies were performed. All uroflowmetry tracings were inspected and analyzed manually. Only patients who voided similar volumes varying by less than 20% on the free and pressure flow studies were assessed. Free and pressure flow parameters were compared according to voided volume category, main urodynamic diagnosis, uroflowmetry pattern and pre-void bladder volume.

Results: A similar volume was voided on the free and pressure flow studies of 100 women. In each voided volume category and urodynamic diagnosis pressure flow parameters were significantly different from the equivalent free flow parameters in all but 4 cases. Specifically the maximum flow rate was significantly less and flow time was significantly longer on pressure versus free flow studies (each $p < 0.01$). An intermittent flow pattern was more common on pressure than in free flow measurements (43% versus 9%).

Conclusions: A 7Fr transurethral catheter may adversely affect uroflowmetry parameters in women undergoing pressure flow studies for lower urinary tract symptoms. This finding may have further clinical implications regarding the interpretation of these parameters as well as establishment of an accurate diagnosis.

KEY WORDS: urodynamics, flowmetry, urethra, bladder, catheterization

Pressure flow studies are considered to be the best method for assessing the voiding phase of the micturition cycle. Ideally the flow pattern of a pressure flow study should be representative of equivalent noninvasive free flow uroflowmetry in the same patient.[1] However, factors associated with the pressure flow technique and setting may affect the voiding process. Specifically using a transurethral catheter may potentially cause urethral irritation and/or relative bladder outlet obstruction during the study. Confirmation or exclusion of these potential effects may improve our ability to interpret pressure flow measurement correctly.

Unfortunately to our knowledge these potential effects have not been well studied in women. Several reports on men demonstrated that transurethral catheters may cause obstructive changes during pressure flow studies.[2–5] These obstructive changes were most pronounced in men with bladder outlet obstruction.[6–8] However, another study suggested that in men with lower urinary tract symptoms due to benign prostatic hyperplasia an 8Fr transurethral catheter does not cause any significant change.[9] This finding implies a possible 8Fr threshold above which a transurethral catheter may impair pressure flow measurement. However, these data are not applicable to women since the voiding process in women is different from that in men. Moreover, data concerning the possible effects of a transurethral catheter on pressure flow measurement in women are limited and controversial.[10–14] Therefore, we performed a study to evaluate whether a 7Fr transurethral catheter affects urinary flow in women undergoing urodynamic evaluation for lower urinary tract symptoms.

MATERIALS AND METHODS

Investigations. We reviewed a urodynamics database of 600 consecutive women referred for the evaluation of lower urinary tract symptoms. All patients underwent a detailed clinical evaluation, including a complete history and physical examination, urinary questionnaire, 24-hour voiding diary and pad test, urine culture, noninvasive free flow uroflowmetry, post-void residual urine volume determination, video urodynamics and urethrocystoscopy. Free flow measurements were made privately with the patient sitting on a standard toilet and they were repeated at least twice to ensure consistency. Post-void residual urine volume was measured by ultrasound immediately after bladder emptying.

Multichannel video urodynamics were performed according to the recommendations of the International Continence Society except for cystometry.[15] Contrary to these recommen-

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dations patients were not instructed to try to inhibit voiding during the filling phase, but rather to report sensations to the examiner. Patients were asked to confirm that voiding complaints were reproduced by the study.

Cystometrography was performed using a 7Fr double lumen transurethral catheter through which room temperature radiographic contrast material was infused at a medium fill rate of 75 to 100 ml. per minute with rectal pressure monitoring. Bladder filling was discontinued at functional bladder capacity, defined as the largest voided volume in a 24-hour voiding diary, or before this point if the patient had a strong desire to void. Further filling was avoided since bladder overfilling may cause a significant decrease in the flow rate.[2] Subsequently patients were asked to void while sitting with the 7Fr transurethral catheter in place. Pressure flow studies were done with simultaneous video fluoroscopy of the bladder outlet. Perineal surface electromyography measurements were also made. If the patient was unable to void with the transurethral catheter in place, it was removed and free flow measurements were made.

Patients and data analysis. The positive correlation of flow rate with voided volume is well established.[16] Therefore, we analyzed only patients who voided a similar volume varying by less than 20% on the free and pressure flow studies. We also evaluated those who were unable to void with the transurethral catheter in place despite bladder filling to functional capacity but who voided a similar volume without the catheter. Patients who voided different volumes that varied by more than 20% in both studies were excluded from analysis. Moreover, since the positive correlation of flow rate with voided volume is partially parabolic, we divided the study population according to the voided volume subsets of 100 or less, 101 to 200, 201 to 300, 301 to 400 and greater than 400 ml.

Further analysis was performed according to the main urodynamic diagnoses, including detrusor instability, defined as involuntary detrusor contractions during bladder filling; sphincteric incontinence, defined as urinary incontinence during physical exertion, such as coughing or the Valsalva maneuver, in the absence of a detrusor contraction; bladder outlet obstruction, defined urodynamically as maximum urine flow less than 12 ml. per second with detrusor pressure at maximum flow greater than 20 cm. H_2O or apparent bladder outlet obstruction during voiding fluoroscopy, and other less common urodynamic diagnoses, such as impaired detrusor contractility, low bladder compliance and normal urodynamic findings despite clinically significant lower urinary tract symptoms.

All uroflowmetry tracings were inspected and analyzed manually. Comparisons were made of spontaneous (free) and intubated (pressure flow) voiding according to voided volume category, the urodynamic diagnosis, flow pattern and prevoiding bladder volume. Free flow parameters included the maximum and average flow rates, flow time, time to maximum flow, voided volume, post-void residual urine and flow pattern. Similarly pressure flow parameters included maximum flow rate, detrusor pressure at maximum flow, maximum detrusor pressure, voided volume, post-void residual urine and flow pattern. Results were analyzed statistically by the Student t and chi-square tests with $p < 0.05$ considered significant.[17] Data are presented as the mean plus or minus standard deviation or percent according to the variables.

RESULTS

Of the 600 consecutive women in the database 117 met our inclusion criteria, including 100 (85.5%) who voided a similar volume varying by less than 20% on the free and the pressure flow studies, and 17 (14.5%) who were unable to void during the pressure flow study but voided a volume equivalent to functional bladder capacity during the free flow study. Those who voided a similar volume in each study were significantly older than those who were unable to void with a transurethral catheter in place (mean 65.1 ± 13.2 versus 55.3 ± 17.3 years, p = 0.005). Table 1 shows patient characteristics in the 2 groups.

TABLE 1. *Patient characteristics*

	Similar Voided Vol. 100	Unable to Void 17
Mean pt. age ± SD	65.1 ± 13.2	55.3 ± 17.3
Mean parity ± SD	2.0 ± 1.4	1.5 ± 1.4
No. previous pelvic surgery (%):		
Hysterectomy	36 (36)	6 (35)
Anti-incontinence	26 (26)	4 (24)
No. urodynamic diagnosis (%):		
Detrusor instability	37 (37)	0
Sphincteric incontinence	33 (33)	6 (35)
Bladder outlet obstruction	13 (13)	4 (24)
Other	17 (17)	7 (41)

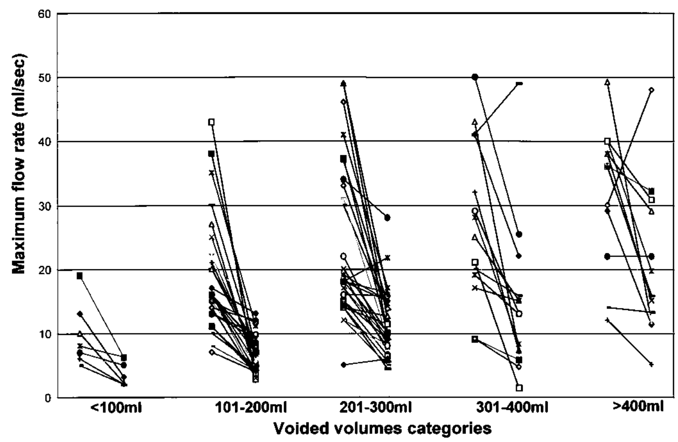

FIG. 1. Free versus pressure flow volume by voided volume category.

Of the 100 women who voided a similar volume on the free and pressure flow studies 8, 31, 33, 15 and 13 voided 100 or less, 101 to 200, 201 to 300, 301 to 400 and greater than 400 ml., respectively. In each voided volume category pressure flow parameters were significantly different from the equivalent free flow parameters in all but 4 cases. Specifically the maximum flow rate was significantly less and flow time was significantly longer on pressure versus free flow studies (fig. 1 and table 2).

A further comparison was made of the 52 women who voided similar volumes and had a similar post-void residual urine volume on free and pressure flow studies, that is a similar pre-void bladder volume (table 3). In each voided volume category pressure flow parameters were again significantly different from the equivalent free flow parameters.

Uroflowmetry curves were classified as continuous—smooth continuous curve without any deflections or interruptions, undulating—upward and downward deflections without interruptions, and intermittent—interrupted curve and return of flow to baseline. Overall a continuous, smooth curve flow pattern was more common in free (64%) than in pressure (41%) flow measurements, while an intermittent interrupted curve flow pattern was more common in pressure (43%) than in free (9%) flow measurements. Figures 2 and 3 show uroflowmetry patterns of free versus pressure flow studies. We further compared 35 women with a continuous, smooth curve flow pattern on free and pressure flow studies. Mean maximum flow rate was significantly higher on free versus pressure flow studies (26.9 ± 12.3 versus 13.9 ± 6.6 ml. per second, $p = 8.6 \times 10^{-7}$), although mean voided and post-void residual urine volumes were similar (278.5 ± 143.2 versus

TABLE 2. *Analysis by voided volume category*

Voided Vol. (ml.)	No. Pts.	Mean ± SD Free Flow	Mean ± SD Pressure Flow	p Value
Less than 100:	8	68.8 ± 21.2	70.9 ± 13.4	0.41
Max. flow rate (ml./sec.)		9.25 ± 4.4	4.0 ± 1.7	0.006
Flow time (sec.)		14.4 ± 9.5	35.9 ± 16.9	0.005
Post-void residual urine vol. (ml.)		65.0 ± 93.1	237.1 ± 182.5	0.02
101–200:	31	157.9 ± 48.7	151.5 ± 31.1	0.27
Max. flow rate (ml./sec.)		18.7 ± 8.4	6.8 ± 3.0	3.7×10^{-10}
Flow time (sec.)		17.8 ± 9.5	52.6 ± 27.2	1.6×10^{-8}
Post-void residual urine vol. (ml.)		57.2 ± 70.1	168.1 ± 122.4	6.2×10^{-5}
201–300:	33	233.9 ± 64.8	248.0 ± 31.3	0.13
Max. flow rate (ml./sec.)		22.5 ± 11.8	11.2 ± 5.1	2.3×10^{-6}
Flow time (sec.)		22.1 ± 10.8	59.7 ± 21.6	8.1×10^{-12}
Post-void residual urine vol. (ml.)		41.7 ± 41.8	117.6 ± 99.1	1×10^{-4}
301–400:	15	329.7 ± 82.3	354.7 ± 26.9	0.14
Max. flow rate (ml./sec.)		27.1 ± 11.9	14.1 ± 11.3	0.003
Flow time (sec.)		24.7 ± 16.1	72.2 ± 40.5	2×10^{-4}
Post-void residual urine vol. (ml.)		48.1 ± 55.4	69.2 ± 67.9	0.19
Greater than 400:	13	438.9 ± 99.4	467.0 ± 68.9	0.2
Max. flow rate (ml./sec.)		32.3 ± 10.3	20.4 ± 11.3	0.006
Flow time (sec.)		27.9 ± 17.8	69.5 ± 44.0	0.003
Post-void residual urine vol. (ml.)		9.4 ± 10.4	32.6 ± 53.1	0.09
Total No.	100			

TABLE 3. *Analysis of similar pre-void bladder volumes by voided volume categories*

Voided Vol. (ml.)	No. Pts.	Mean ± SD Free Flow	Mean ± SD Pressure Flow	p Value
101–200:	10	164.2 ± 36.6	160.4 ± 29.1	0.4
Max. flow rate (ml./sec.)		18.9 ± 10.7	7.8 ± 3.1	0.004
Flow time (sec.)		18.3 ± 9.3	55.8 ± 34.4	0.004
Post-void residual urine vol. (ml.)		49.1 ± 52.6	59.2 ± 65.3	0.4
201–300:	20	219.2 ± 55.7	248.8 ± 29.3	0.02
Max. flow rate (ml./sec.)		23.2 ± 12.8	11.0 ± 4.6	2×10^{-4}
Flow time (sec.)		19.6 ± 10.8	60.9 ± 25.1	1.5×10^{-7}
Post-void residual urine vol. (ml.)		52.1 ± 43.2	52.8 ± 48.8	0.5
301–400:	10	335.5 ± 92.9	354.9 ± 29.6	0.3
Max. flow rate (ml./sec.)		29.8 ± 12.7	15.4 ± 13.3	0.01
Flow time (sec.)		24.0 ± 13.1	80.5 ± 39.2	5×10^{-4}
Post-void residual urine vol. (ml.)		34.8 ± 40.3	49.4 ± 43.2	0.2
Greater than 400:	12	443.1 ± 102.4	464.9 ± 71.3	0.3
Max. flow rate (ml./sec.)		34.0 ± 8.8	21.7 ± 10.8	0.004
Flow time (sec.)		26.3 ± 17.7	60.3 ± 31.6	0.003
Post-void residual urine vol. (ml.)		8.3 ± 10.3	20.4 ± 33.4	0.2
Total No.	52			

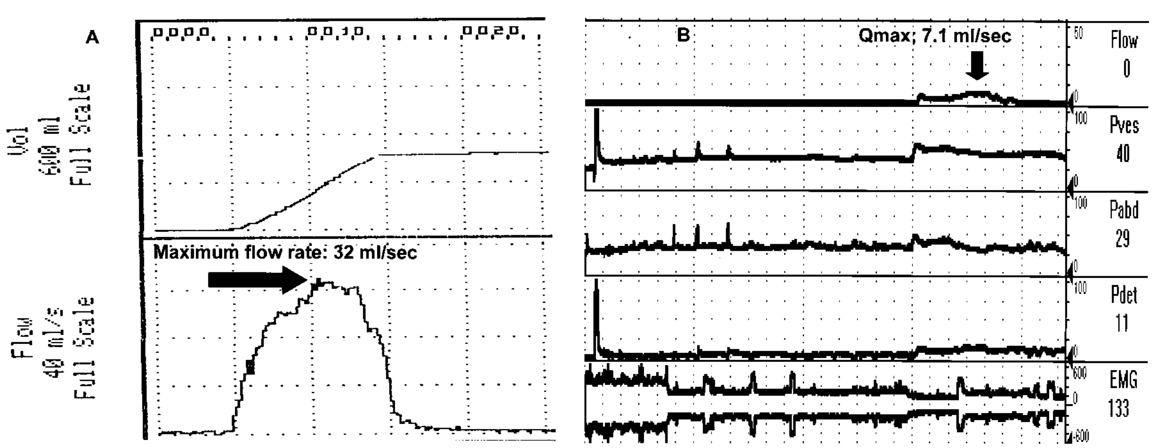

FIG. 2. Sphincteric incontinence in 31-year-old woman. *A*, free flow study shows 246 ml. voided volume (*Vol*), 32 ml. per second maximum flow and normal continuous pattern. *B*, pressure flow study shows 305 ml. voided volume, 7.1 ml. per second maximum flow (*Qmax*) and flat undulating pattern. Unequal transmission of abdominal pressure to bladder during filling was mechanical artifact that was considered when interpreting study by manual inspection of tracings. *Pves*, vesical pressure. *Pabd*, abdominal pressure. *Pdet*, detrusor pressure. *EMG*, electromyography.

298.1 ± 131.5 and 44.9 ± 54.8 versus 70.1 ± 79.4 ml., respectively, fig. 4).

The main urodynamic diagnosis in the 100 women who voided a similar volume on free and pressure flow studies was detrusor instability in 37, sphincteric incontinence in 33 and bladder outlet obstruction in 13, while there was another far less common urodynamic diagnosis in 17. In each voided volume category pressure flow parameters were significantly different from the equivalent free flow parameters. Specifically the maximum flow rate was significantly less and flow

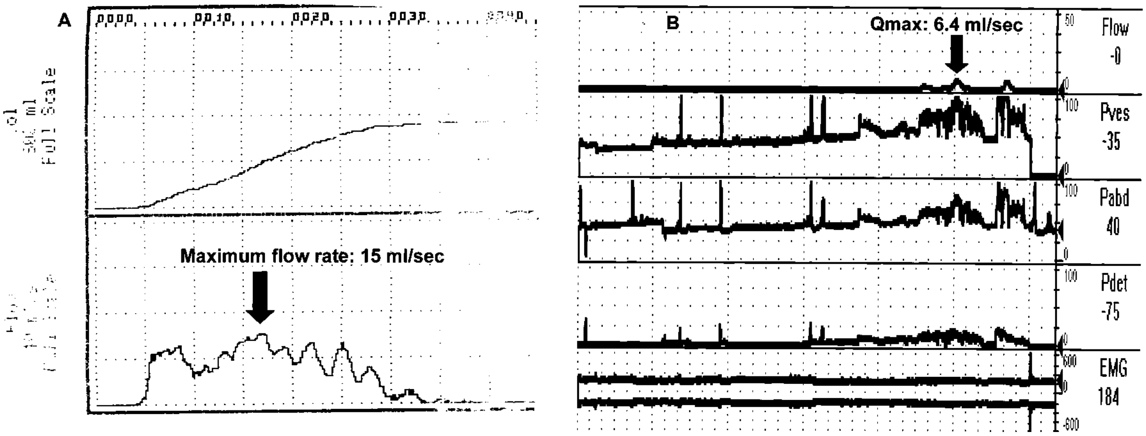

FIG. 3. Sphincteric incontinence in 62-year-old woman. *A*, free flow study demonstrates 281 ml. voided volume, 15 ml. per second maximum flow and undulating pattern. *B*, pressure flow study reveals 267 ml. voided volume, 6.4 ml. per second maximum flow (*Qmax*) and interrupted pattern. Unequal transmission of abdominal pressure to bladder during filling was mechanical artifact that was considered when interpreting study by manual inspection of tracings. *Pves*, vesical pressure. *Pabd*, abdominal pressure. *Pdet*, detrusor pressure. *EMG*, electromyography.

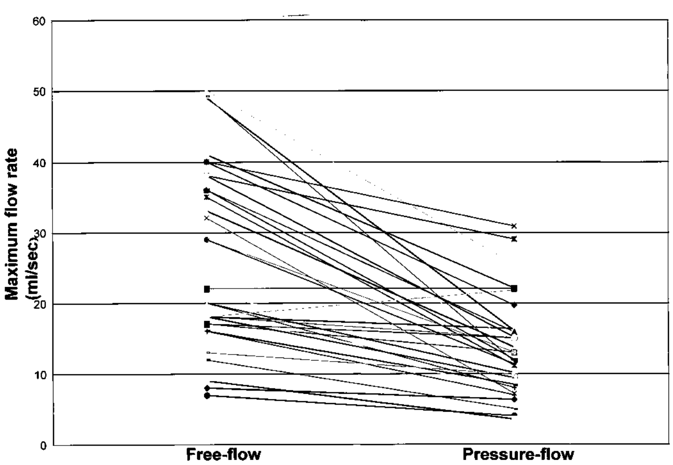

FIG. 4. Continuous smooth curve flow patterns of free versus pressure flow studies.

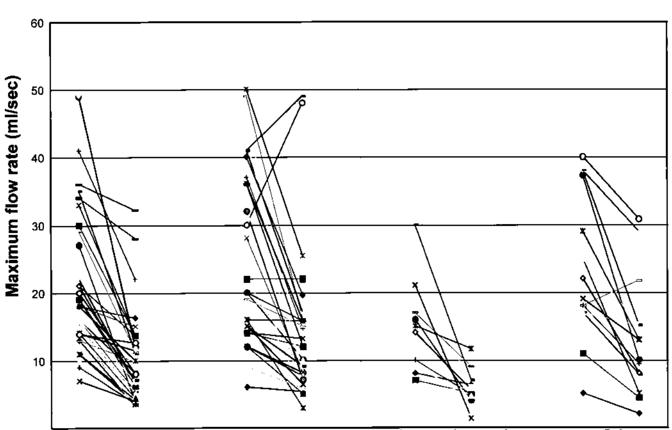

FIG. 5. Free versus pressure flow volume by urodynamic diagnosis

time was significantly longer on pressure versus free flow studies (fig. 5 and table 4).

DISCUSSION

The emptying phase of the micturition cycle has been thoroughly studied in male populations but previous research in female populations is limited. The availability and increased use of various treatment modalities as well as new imaging techniques recently revived clinical awareness and interest in female bladder outlet obstruction. Diagnosing this dysfunction is fundamentally based on pressure flow studies. However, data on pressure flow studies, specifically the possible impact of the transurethral catheter in women, are sparse. The results of our study imply that a 7Fr transurethral catheter may adversely affect uroflowmetry parameters in women undergoing pressure flow studies for lower urinary tract symptoms. This finding may have further clinical implications on interpreting these parameters as well as on establishing an accurate diagnosis.

Few previously published studies have investigated the clinical consequences of transurethral catheterization during pressure flow studies in women,[11–14] and the results are controversial. In 1984 Gleason and Bottaccini investigated the effect of a 5Fr urethral pressure measuring catheter on urinary flow in 221 women referred for evaluation of lower urinary tract symptoms and 21 healthy female volunteers.[11] Transurethral catheterization adversely affected the configuration of the flow curves, inducing an intermittent or flat obstructive flow pattern in 47% of the cases. Furthermore, the transurethral catheter was associated with a significant decrease in the flow rate that was highly significant in the normal and stress incontinent groups but not statistically significant in patients with urge incontinence or difficult voiding. Although the decreased flow rate occurred despite a higher volume voided during pressure flow voiding and the known positive correlation of voided volume with flow rate, further analysis according to similar voided volumes was not done. It is possible that such analysis would have established statistical significance in all categories.

In 1986 Lose et al compared free and pressure flow rates in 60 women with lower urinary tract disorders.[12] They noted no change in maximum flow when 2, 5Fr transurethral catheters were inserted, whereas the average flow rate decreased. However, voided volume in that series was significantly greater on pressure flow studies, which probably explained the elevated maximum flow rate observed. In 1989 Sorensen et al assessed 22 healthy female volunteers and noted that a 7Fr transurethral catheter may cause a significant decrease in the maximum and average flow rates as well as prolongation of voiding time.[13]

To our knowledge no additional peer reviewed studies addressing this issue have been published since 1989. Most recently, Haylen et al presented an abstract on the effect of a 7Fr transurethral catheter on the urinary flow rate in 145 symptomatic women.[14] The urinary flow rate was corrected

TABLE 4. *Analysis by urodynamic diagnosis*

Diagnosis	No. Pts.	Mean ± SD Free Flow	Mean ± SD Pressure Flow	p Value
Detrusor instability:	37	194.1 ± 100.5	207.8 ± 96.6	0.3
Max. flow rate (ml./sec.)		21.0 ± 10.7	9.8 ± 6.6	4.5×10^{-7}
Flow time (sec.)		19.1 ± 10.6	55.4 ± 22.2	6.2×10^{-13}
Post-void residual urine vol. (ml.)		51.4 ± 63.0	142.7 ± 118.4	5.7×10^{-5}
Detrusor pressure at max. flow (cm. H_2O)			24.5 ± 35.4	
Sphincteric incontinence:	33	301.9 ± 132.4	310.3 ± 126.5	0.4
Max. flow rate (ml./sec.)		26.1 ± 12.9	13.2 ± 10.4	2.1×10^{-5}
Flow time (sec.)		23.7 ± 16.6	70.9 ± 40.7	1.9×10^{-7}
Post-void residual urine vol. (ml.)		30.5 ± 34.7	97.0 ± 123.4	0.003
Detrusor pressure at max. flow (cm. H_2O)			17.9 ± 13.9	
Bladder outlet obstruction:	13	164.5 ± 74.2	178.3 ± 89.4	0.3
Max. flow rate (ml./sec.)		13.2 ± 6.7	5.9 ± 2.7	9×10^{-4}
Flow time (sec.)		23.0 ± 11.8	60.0 ± 33.1	8×10^{-4}
Post-void residual urine vol. (ml.)		50.1 ± 54.0	128.4 ± 76.2	0.007
Detrusor pressure at max. flow (cm. H_2O)			33.6 ± 19.0	
Other:	17	266.7 ± 111.7	270.0 ± 117.4	0.5
Max. flow rate (ml./sec.)		24.3 ± 10.4	12.6 ± 7.8	6×10^{-4}
Flow time (sec.)		20.4 ± 9.8	41.3 ± 18.4	3×10^{-4}
Post-void residual urine vol. (ml.)		61.4 ± 82.1	138.6 ± 141.6	0.04
Detrusor pressure at max. flow (cm. H_2O)			19.7 ± 5.8	
Total No.	100			

for voided volume by converting to urinary flow centiles of published nomograms. Surprisingly the 7Fr transurethral catheter had a mildly favorable effect rather than the expected detrimental effect on the urinary flow rate. They speculated that the reason for this favorable finding may have been a stenting effect of the catheter at a higher voided volume that assisted urinary flow. Since detailed data were not provided, it is difficult to argue against the unexpected results. Furthermore, since established flow nomograms in women have not been fully validated on large studies, we prefer not to use them in our cases. Therefore, we elected to compare directly similar voided volumes on free and pressure flow studies. In each voided volume category and urodynamic diagnosis pressure flow parameters were significantly different from the equivalent free flow parameters in almost all patients. Specifically the maximum flow rate was significantly less and flow time was significantly longer on pressure versus free flow studies. In addition, pressure flow studies were associated with a significant interruption of the flow pattern. These results suggest that a 7Fr transurethral catheter may adversely affect uroflowmetry parameters in women undergoing pressure flow studies for lower urinary tract symptoms.

We further studied the characteristics of women who were unable to void with a transurethral catheter in place but who voided a volume equivalent to functional bladder capacity without the catheter. They were significantly younger than those who voided with a transurethral catheter in place. The correlation of age with test induced dysfunctional voiding is obscure. Sorensen et al compared free with pressure flow in 10 young and 12 postmenopausal healthy women.[13] Although a 7Fr transurethral catheter was associated with significantly decreased maximum and average flow rates as well as increased flow time in each group, the differences were most pronounced in younger women. It is possible that the association of the inability to void with urethral catheter placement and younger age in our study represents the extreme of a similar phenomenon. Whether this observation is the result of psychological or physiological factors remains to be established.

If flow is decreased with the urethral catheter in place, there are a number of possible explanations, including dysfunctional voiding because the patient contracts the sphincter due to discomfort, lower voided volume also due to discomfort and bladder outlet obstruction caused by the urethral catheter. When a 7Fr urethral catheter causes obstruction, it may imply that urethral compliance is decreased. To our knowledge no previously published study addresses low urethral compliance in women. Furthermore, Schafer described constrictive and compressive urethral obstruction.[18] In constrictive obstruction the urethral cross-sectional area is decreased. Although a small transurethral catheter has no clinically significant effect on compressive obstruction, as in male benign prostatic hyperplasia and female genitourinary prolapse, it may cause significant additional obstruction in an already constricted urethra, such as when urethral stricture or fibrosis is present. Unlike data reported in men, we did not detect more pronounced catheter induced changes in women with bladder outlet obstruction than in those with another urodynamic diagnosis. This finding may be due to the relatively small number of patients with bladder outlet obstruction in our series or the cause of bladder outlet obstruction in our patients. Further studies of larger series of women with bladder outlet obstruction are needed to address this issue.

CONCLUSIONS

Pressure flow studies are currently the best method to assess the emptying phase of the voiding cycle in men and women. However, the technique and setting may adversely affect test results. Clinical awareness of these limitations as well as exploration of possible changes and their extent may improve our understanding of and ability to make the correct diagnosis in women with lower urinary tract symptoms.

REFERENCES

1. Griffiths, D., Hofner, K., van Mastrigt, R. et al: Standardization of terminology of lower urinary tract function: pressure-flow studies of voiding, urethral resistance, and urethral obstruction. Neurourol Urodyn, **16:** 1, 1997
2. Ryall, R. L. and Marshall, V. R.: The effect of a urethral catheter on the measurement of maximum urinary flow rate. J Urol, **128:** 429, 1982
3. Lose, G., Thunedborg, P., Colstrup, H. et al: Spontaneous versus intubated flow in male patients. Urology, **32:** 553, 1988
4. Klinger, H. C., Madersbacher, S. and Schmidbauer, C. P.: Impact of different sized catheters on pressure-flow studies in patients with benign prostatic hyperplasia. Neurourol Urodyn, **15:** 473, 1996
5. Walker, R. M., Di Pasquale, B., Hubregtse, M. et al: Pressure-flow studies in the diagnosis of bladder outlet obstruction: a study comparing suprapubic and transurethral techniques. Br J Urol, **79:** 693, 1997
6. Griffiths, D. J. and Scholtmeijer, R. J.: Precise urodynamic assessment of anatomic urethral obstruction in boys. Neurourol Urodyn, **1:** 97, 1982

7. Reid, R. E., Chandrasekar, D., Pugach, R. et al: Effect of varying size of urethral catheters upon flow and resistance measurements. Neurourol Urodyn, **5:** 277, 1986
8. Neal, D. E., Rao, C. V., Styles, R. A. et al: Effects of catheter size on urodynamic measurements in men undergoing elective prostatectomy. Br J Urol, **60:** 64, 1987
9. Reynard, J. M., Lim, C., Swami, S. et al: The obstructive effect of a urethral catheter. J Urol, **155:** 901, 1996
10. Griffiths, D. J. and Scholtmeijer, R. J.: Precise urodynamic assessment of meatal and distal urethral stenosis in girls. Neurourol Urodyn, **1:** 89, 1982
11. Gleason, D. M. and Bottaccini, M. R.: The effect of a fine urethral pressure-measuring catheter on urinary flow in females. Neurourol Urodyn, **3:** 163, 1984
12. Lose, G., Thunedborg, P., Jørgensen, L. et al: A comparison of spontaneous and intubated urinary flow in female patients. Neurourol Urodyn, **5:** 1, 1986
13. Sorensen, S., Jonler, M., Knudsen, U. B. et al: The influence of a urethral catheter and age on recorded urinary flow rates in healthy women. Scand J Urol Nephrol, **23:** 261, 1989
14. Haylen, B. T., Cerqui, A., Law, M. et al: Effect of size 7FG urethral catheter on urine flow rates in urogynaecology patients. Int Urogynecol J, suppl., **10:** S98, abstract, 1999
15. Abrams, P., Blaivas, J. G., Stanton, S. L. et al: Standardisation of terminology of lower urinary tract function. International Continence Society Committee on Standardization of Terminology. Neurourol Urodyn, **7:** 403, 1988
16. Drach, G. W., Layton, T. N. and Binard, W. J.: Male peak urinary flow rate: relationships to volume voided and age. J Urol, **122:** 210, 1979
17. Altman, D. G.: Practical Statistics for Medical Research. London: Chapman and Hall, pp. 241–265, 1991
18. Schafer, W.: The contribution of the bladder outlet to the relation between pressure and flow rate during micturition. In: Benign Prostatic Hypertrophy. Edited by F. Hinman, Jr. and S. Boyarsky. New York: Springer-Verlag, pp. 470–496, 1983