Urol Res (1994) 22:235–238

ORIGINAL PAPER

D. Griffiths · G. Harrison · K. Moore · P. McCracken

Long-term changes in urodynamic studies of voiding in the elderly

Received: 5 April 1994/Accepted: 3 June 1994

Abstract Urodynamic studies were conducted in 80 incontinent elderly patients (27 men and 53 women; mean age, 77 years) and repeated 2–4 weeks later after patients had been subject to interventions. Interpretable voiding studies were performed in 84% of sessions. Interpretable initial and repeat studies were performed in 74% of patients. For detrusor pressure at maximum flow the intra-individual, between-sessions variability was ±11.7 cm H_2O (SD) and the initial-repeat correlation coefficient was 0.61. For maximum flow rate the corresponding figures were ±4.7 ml/s and 0.44. Mean residual urine volume was 195 ml, with a between-sessions variability of ±113 ml (SD). These results suggest that there is substantial long-term variability in voiding function, including urethral resistance. Of the men, 5% showed a change in obstruction classification (unobstructed/obstructed) between sessions. This variability and the modest proportion of interpretable studies should be taken into account when assessing urethral obstruction and designing clinical trials.

Key words Urethral obstruction · Detrusor pressure · Urine flow rate · Pressure/flow studies · Clinical trials

Urodynamic measurements of pressure and flow rate during voiding have been made for over 40 years [10] and have become the accepted standard for objective assessment of urethral obstruction [2]. The reproducibility of repeated measurements made during a single session is satisfactory [5, 12]. Surprisingly little is known about the long-term variability of measurements made weeks or months apart; Sorensen and associates [13] have examined this in ten females. Because of the scarcity of data it is difficult to plan clinical trials, for example of non-surgical treatments of obstruction due to benign prostatic hyperplasia (J.D. McConnell, personal communication). For planning trials it is equally important to know what proportion of urodynamic tests yield interpretable pressure/flow data.

As part of a comprehensive study of geriatric incontinence we have performed, in 80 elderly patients, two urodynamic studies of voiding, separated by an interval of 2–4 weeks. From these observations we have determined both the proportion of urodynamic sessions that gave interpretable pressure/flow data and the long-term variability of these measurements. Two limitations which may hinder generalization of the results are: (1) the elderly and infirm patient population and (2) the fact that a behavioural and/or medical intervention for incontinence was carried out between the initial and repeat sessions. Even so, these results are important because data on long-term variability are so scarce.

Materials and methods

Patients with symptoms of urinary incontinence were referred from a tertiary geriatric assessment and rehabilitation facility. Bedridden patients and those with an indwelling urethral catheter were excluded. Written, informed consent was obtained from the patient and if necessary from a close relative or guardian. Drugs prescribed to influence bladder function were discontinued 1 week before the investigations. Other drugs judged necessary by the patient's physician were continued.

Further initial investigations included physical examination (including a simple neurological examination), history, assessment of activities of daily living [9], cognitive testing with the Mini-mental State Examination [3], urinalysis, urine culture and sensitivity, 24-h monitoring of incontinence and bladder function [6] and urodynamic study of bladder filling, voiding and incontinence episodes.

D. Griffiths (✉)
Urodynamics Unit, Edmonton General Hospital,
11111 Jasper Avenue, Edmonton, Alberta T5K 0L4, Canada

G. Harrison · K. Moore
Department of Applied Sciences in Medicine, University of Alberta, Edmonton, Canada

P. McCracken
Department of Geriatrics, Edmonton General Hospital, Edmonton, Canada

Table 1 Results of initial and repeat pressure/flow studies in 18 patients not receiving oxybutynin chloride [SD standard deviation, *P*, probability of difference between initial and repeat sessions (by *t*-test), *r*, Pearson coefficient of correlation between initial and repeat sessions]

		n	Initial session mean±SD mean	Repeat session ±SD	*P*	Between sessions SD	*r*
Q_{max}	ml/s	18	9.6± 8.5	8.9± 7.3	0.72	± 5.4	0.54
$P_{det,Qmax}$	cm H_2O	18	31.3± 30.2	26.0± 19.2	0.30	± 14.8	0.73
PVR	ml	18	294 ±295	301 ±214	0.85	±113	0.85

Table 2 Results of initial and repeat pressure/flow studies in all 59 patients with interpretable studies in both sessions [SD standard deviation, *P*, probability of difference between initial and repeat sessions (by *t*-test), *r*, Pearson coefficient of correlation between initial and repeat sessions]

		N	Initial session mean±SD	Repeat session mean±SD	*P*	Between sessions SD	*r*
Q_{max}	ml/s	59	9.6± 6.5	9.7± 6.3	0.89	± 4.8	0.44
$P_{det,Qmax}$	cm H_2O	59	29.8± 20.6	27.3± 16.1	0.25	± 11.7	0.61
PVR	ml	59	195 ±207	257 ±197	0.007	±120	0.64
URA	cm H_2O	59	19.7± 15.9	18.1± 12.2	0.34	± 12.3	0.64

On the basis of these investigations an intervention was recommended. Two to 4 weeks later the patient was reassessed with repeat 24-h monitoring and urodynamics. Interventions included oxybutynin chloride in doses ranging from 2.5 mg h.s. to 5 mg t.i.d., regular voiding or toiletting, timed fluid intake restriction and electrical stimulation. For the purpose of this study, any patients receiving surgery (e.g. for obstruction or stress incontinence) were excluded. Results for patients receiving oxybutynin chloride were excluded initially and subsequently included when it became clear that the medication did not increase the variability.

Urodynamics was performed with the patient in the supine and sitting positions, using a Laborie UDS-500 urodynamics analyser, a Philips BV 22 fluoroscope and a table/chair specially designed for investigating elderly immobile patients. Methods and definitions followed the standards recommended by the International Continence Society [8]. Fluid-filled urethral and rectal catheters (5 and 10 French gauge) were connected to external pressure transducers placed at the level of the upper edge of the symphysis pubis. Pelvic-floor EMG was recorded from a disposable sphincter electrode placed in the rectum. The bladder was filled through a second urethral catheter (8 French gauge) with room-temperature radiographic contrast medium (Conray 30) at a medium rate (70 ml/min). Stress testing and checking of the pressure lines were performed by asking the patient to cough. Filling was continued until there was a very strong desire to void, uninhibitable voiding occurred or the detrusor pressure rose markedly. The patient voided into a flowmeter placed under the table, in the sitting position if possible. In some cases the bladder was refilled and voiding repeated, although this was not usually profitable with these elderly people, who were prone to rapid fatigue.

Uninterpretable studies in which the patient failed to void or a technically reliable pressure measurement was not obtained were eliminated. The following measured variables were then examined: maximum flow rate (Q_{max}), detrusor pressure at maximum flow ($P_{det,Qmax}$) and post-void residual urine (PVR). If filling and voiding were repeated in the same session, the highest maximum flow rate, the lowest detrusor pressure at maximum flow and the smallest post-void residual were used. In addition, the group-specific urethral resistance factor URA [7] was computed. If voiding was repeated, the lowest value was used.

For each of these four variables variability between the initial and repeat sessions was examined as follows. Possible systematic changes were examined by *t*-tests. Intra-individual random variations from one session to the next were determined by repeated-measures analysis of variance, the result being expressed as a between-sessions standard deviation. (This standard deviation is also equal to the standard deviation of the intra-individual differences between initial and repeat values, divided by $\sqrt{2}$.) The Pearson coefficient of correlation between initial and repeat values was calculated as a measure of reproducibility. Possible differences between men and women were examined by *t*-tests (for mean values) and *F*-tests (for variances or standard deviations).

For males, URA=29 cm H_2O is a critical value separating obstructed from not clearly obstructed cases [11]. The number of men classified as obstructed by this criterion was examined in the first and second sessions.

Results

Eighty patients qualified for the study, 27 men and 53 women. Their mean age was 77 years (range 60–89 years). The mean Mini-mental State Score ranged from 7/30 to 30/30 with a mean of 22/30, corresponding to slight dementia [3]. The median activities of daily living score ranged from A to H with a median of C, corresponding to inability to perform one of the activities of daily living in addition to incontinence [9]. Patients had clinical diagnoses as follows: Alzheimer's disease (17), Parkinson's disease (10), multi-infarct dementia (8), normal pressure hydrocephalus (2) and multiple sclerosis (2). Twenty-four patients had no history or sign of any significant neurological disease. Interpretable pressure/flow studies of voiding were obtained in 70/80 (88%) patients on initial examination, and in 64/80 (80%) patients on repeat examination 2–4 weeks later. Nearly all studies which were not interpretable failed because the patient did not void. In 59/80 patients (74%) both the initial and the repeat studies were interpretable, allowing assessment of variability. Only 1 patient (with multiple sclerosis) showed evidence of detrusor-sphincter dyssynergia during voiding.

The interventions were as follows for the 59 patients: 41 patients received oxybutynin chloride in doses from 2.5 mg h.s. to 5 mg t.i.d. For 19 patients evening fluid

Table 3 Differences between men and women in initial mean values and in variability from session to session [SD standard deviation, *P*, probability of difference between the variances (standard deviations) in men and women by the *F*-test]

		Initial session mean		Between-sessions SD		
		Women n=37	Men n=22	Women n=37	Men n=22	P
Q_{max}	ml/s	9.9	9.1	± 5.6	± 2.8	0.001
$P_{det,Qmax}$	cm H_2O	22	43	± 11.8	± 11.7	0.98
PVR	ml	241	117	±108	±143	0.14

restriction was suggested, for 33 regular toiletting or voiding, for 1 electrical stimulation; in 1 medication was reduced and in 2 intermittent catheterization was suggested.

Since oxybutynin chloride might in principle affect the results of urodynamic testing, while the other interventions are unlikely to, we first examined measurements in the 18 patients who did not receive the drug (Table 1). There were no significant differences between the initial and repeat sessions.

We then performed similar calculations for all 59 patients with interpretable pressure/flow studies (Table 2). There were only minor differences from Table 1 except that post-void residual now increased significantly after the intervention, reflecting the action of oxybutynin chloride. Comparison of Tables 1 and 2 shows that the between-sessions variability of Q_{max} and $P_{det,Qmax}$ was smaller among the full 59 patients than among the 18 not receiving oxybutynin chloride. Thus there was certainly no evidence that oxybutynin chloride increased the variability of pressure/flow studies.

The variability of the group-specific urethral resistance factor URA was similar to that of detrusor pressure and flow rate (Table 2). Of the 22 men with 2 interpretable pressure-flow studies, 5 were classified as obstructed (URA > 29 cm H_2O) in the first session and 6 in the second. One man (5%) changed classification between the initial and repeat sessions.

Finally, we examined differences between men and women (Table 3). On average, detrusor pressure at maximum flow was lower in females, but the variability between sessions was similar in both sexes. Maximum flow rate was significantly less variable from session to session in males.

Discussion

In this patient population, we were able to perform an interpretable pressure/flow study in 84% of urodynamic sessions. Two successful pressure/flow studies, separated by an interval of 2–4 weeks, were performed in 74% of the patients.

These frail elderly patients voided relatively poorly, with low flow rates and large post-void residual urine (Tables 1, 2). The random variability of the measurements between sessions was large: the between-sessions standard deviation of the detrusor pressure at maximum flow was 11.7 cm H_2O and the correlation coefficient between repeated measurements was only 0.61; for maximum flow rate the between-sessions standard deviation was 4.8 ml/s and the correlation coefficient was even smaller, 0.44. The between-sessions standard deviation of post-void residual urine was 113 ml for those who did not receive oxybutynin chloride; however, this high value is specific to this population, which had a large volume of residual urine (initial mean value, 195 ml) after pressure/flow studies.

The variability of flow rate and detrusor pressure from session to session is too large to be attributed just to technical measurement errors. Flow rates can probably be measured to ±2 ml/s. Intravesical and abdominal pressures are affected by imprecise levelling of the external pressure transducers, but detrusor pressure is not. Detrusor pressure is affected by random errors in both intravesical and abdominal pressures, but it is difficult to see how the total technical error can be greater than about ±5 cm H_2O. The origin may therefore be physiological.

The variability of detrusor pressure from session to session is similar in men and women, even though the actual pressures are twice as high in men. Thus there is a source of variation in the measurements which is not sensitive to the actual size of the pressure. Although it is possible that this variability is characteristic of older patients, comparisons between ambulatory and laboratory measurements have demonstrated similar variability in younger patients of both sexes [1, 14]. In measurements over a 2-year period in ten healthy younger females, the detrusor pressure at maximum flow showed a between-sessions variability of 8 cm H_2O (SD), superimposed on an unexplained systematic increase of 8 cm H_2O [13]. For maximum flow rate the standard deviation of the between-sessions variability was 4.4 ml/s. Because of the form of the normal urethral resistance relation [4], especially in women, detrusor pressure does not vary greatly with flow rate and so substantial changes in voiding detrusor pressure can only occur if the urethral resistance changes. Consequently our observations imply that there is considerable long-term variability in urethral resistance. This conclusion is confirmed by the calculations of the group-specific resistance factor URA. Of the males, 5% showed a change in classification of obstruction (based on URA) between the first and second sessions.

The variability of urethral resistance that we have observed requires confirmation from studies in other patient populations, but has obvious implications for the assessment of urethral obstruction and the design of clinical trials.

Acknowledgements This research was supported by a grant from the Alberta Heritage Foundation for Medical Research. We are grateful to Dr. Ann Gormley FRCS(C) for help with some of the urodynamic studies.

References

1. Abbott D, Khullar V, Cardozo LD, Kelleher CJ (1993) Voiding pressures: changes due to detrusor fatigue? Neurourol Urodyn 12:326
2. Cockett ATK, Khoury S, Aso Y, Chatelain C, Denis L, Griffiths K, Murphy G (eds) (1993) Second international consultation on benign prostatic hyperplasia, proceedings. SCI, Jersey, p 202, p 558
3. Folstein MF, Folstein SE, McHugh PR (1975) 'Mini-mental state': a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 12:189
4. Griffiths DJ (1980) Urodynamics: the mechanics and hydrodynamics of the lower urinary tract. Hilger, Bristol, p 84
5. Griffiths DJ, Scholtmeijer RJ (1982) Precise urodynamic assessment of anatomic urethral obstruction in boys. Neurourol Urodynam 1:97
6. Griffiths DJ, McCracken PN, Harrison GM, Gormley EA (1992) Characteristics of urinary incontinence studied by 24-hour monitoring and urodynamic testing. Age Ageing 21:195
7. Griffiths D, Van Mastrigt R, Bosch R (1989) Quantification of urethral resistance and bladder function during voiding, with special reference to the effects of prostate size reduction on urethral obstruction due to benign prostatic hyperplasia. Neurourol Urodynam 8:17
8. International Continence Society (1988) Standardisation of terminology of lower urinary tract function. Neurourol Urodyn 7:403
9. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffee MW (1963) Studies of illness in the aged: the index of ADL: a standardized measure of biological and social function. JAMA 185:914
10. Miller E (1979) The beginnings. Urol Clin North Am 6:7
11. Rollema HJ, Mastrigt R van (1992) Improved indication and followup in transurethral resection of the prostate using the computer program CLIM: a prospective study. J Urol 148:111
12. Schäfer W (1990) Basic principles and clinical application of advanced analysis of bladder voiding function. Urol Clin North Am 17:553
13. Sorensen S, Gregersen H, Sorensen SM (1988) Long term reproducibility of urodynamic investigations in healthy fertile females. Scand J Urol Nephrol [Suppl] 114:35
14. Webb RJ, Griffiths CJ, Ramsden PD, Neal DE (1990) Measurement of voiding pressures on ambulatory monitoring: comparison with conventional cystometry. Br J Urol 65:152