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Factors causing differences in voiding parameters between conventional and ambulatory urodynamics

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Abstract Voiding parameter values measured with ambulatory urodynamic monitoring (AM) are generally found to be different from those measured with conventional cystometry (CMG). The reason for this is unclear, but might be related to differences in the voided volume. To verify this hypothesis, we compared voidings from female patients at an initial bladder volume that was close to the modal volume (that is, the volume most often voided by the patient as derived from frequency/volume charts) with voidings at maximum cystometric capacity during a routine video urodynamic examination. A first group of 35 patients voided at the modal volume before they did at capacity. The order was reversed in a second group of 12 patients. The dependence of the voiding parameters on the voided volume and the order of the measurements were examined. It was found that the maximum flow rate depended significantly on the voided volume, but the associated detrusor pressure did not. Urethral resistance and bladder contraction strength were not volume dependent either. It was concluded that the differences between AM and CMG cannot be explained from possible differences in the voided volume.

Key words Urodynamics · Cystometry · Bladder volume · Pressure/flow analysis · Ambulatory monitoring

Introduction

In the last decade, ambulatory urodynamic monitoring (AM) has been applied to a variety of urologic abnormalities [7]. It has been recognized that the values of several parameters measured with this technique differ from the values measured with conventional cystometry (CMG). In particular, the flow rate and the detrusor pressure during voiding are generally higher in AM than in CMG [7]. The cause of this difference is unclear. At least four differences between the two techniques can be identified [7]

1. The bladder is filled at a physiological rate in AM, while this is usually not the case in CMG.
2. The patient is fully ambulant and voids in private in AM, while CMG is performed in circumstances that are more or less embarrassing.
3. The bladder volume at which the patient initiates voiding is generally lower in AM than in CMG.
4. Pressure is mostly measured with microtip transducers in AM, while fluid filled catheters are often used in CMG.

The influence of the filling rate has been discussed by several authors, including Robertson et al. [10]. They observed that the voiding pressure was lower when the bladder had been filled more rapidly. However, the voided volumes were also different at the different filling rates. The type of catheter used is, most likely, irrelevant [8, 17]. The aim of the present study was to examine if the dependency of voiding parameters on the initial bladder volume might explain the different results found in CMG and AM. This was done by comparing the values of voiding parameters at two different volumes, measured with one technique, CMG.

Patients and methods

Successive female patients who had completed two or three frequency/volume charts before they underwent a video urodynamic examination were included. The charts were analysed by determining the modal volume, which is the most frequently voided volume. The mean of the reported voided volumes was calculated and used instead of the modal volume in case the latter represented an extremum or could not uniquely be identified. A routine video urodynamic examination in our department consists of a free flow

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followed by two filling cystometries and pressure/flow studies. The bladder is filled to maximum cystometric capacity at a medium rate, the first measurement in the supine position and the second one in the standing position. Voiding takes place in the standing position. For the present study, the two filling/voiding cycles were preceded by a filling to the modal volume in the patients who underwent the examination between February 1996 and October 1997. These patients comprised group 1. In a second group, undergoing the examination between November 1997 and July 1998, the patients voided at the modal volume *after* the routine examination. Patients and measurements were only included when the patient succeeded at both volumes in voiding in the standing position with the urodynamic staff present and when the residue did not exceed 50 ml.

The following parameters were derived from the pressure/flow studies: the voided volume, the residual volume, the initial bladder volume (the sum of the voided and the residual volume), the maximum flow rate Q_{max}, the detrusor pressure $p_{det.Qmax}$ at the maximum flow rate, the urethral resistance and the bladder contraction strength. Urethral resistance was characterised by the parameter URA [4] and by the average pressure $p_{low.ave}$ and the slope s_{low} of the low pressure side of the pressure/flow plot [9, 16]. Bladder contraction strength was characterized by the parameter w [3]; both its maximum value w_{max} and its value at maximum flow rate w_{Qmax} were used.

The results at maximum cystometric capacity in both groups were compared with the unpaired *t*-test. In group 1, the parameters derived from voidings at the modal volume (the first measurement) were compared with those derived from voidings at the *maximum* cystometric capacity (either the second or the third measurement in order to maximise the difference between the initial volumes). In group 2, the first measurement (at capacity) was compared with the last one (at the modal volume). The two-tailed paired *t* test was used for this. Finally, simple factorial analysis of variance (SPSS) was applied to the combined groups to assess the dependency of the voiding parameters on the initial bladder volume (modal volume vs cystometric capacity) and the rank number of the measurement (first vs second or third measurement). The level of significance was set at 0.05. Methods, definitions and units conform to the standards recommended by the International Continence Society, except where specifically noted.

Results

A total of 92 females entered study group 1, that is, the group in which the pressure/flow study at the modal volume preceded those at maximum cystometric capacity. Of these patients, 44 could not void at both volumes under the same circumstances and were excluded from the study. Thirteen additional patients were excluded because of artifacts or residual volumes exceeding 50 ml. The mean age of the 35 patients whose data were analysed was 46 (range 21–73) years. In 15 patients, stress incontinence was demonstrated during the urodynamic examination, six showed bladder instability and in four both abnormalities were found. Although eight patients showed poor or intermittent relaxation during voiding, none of them was obstructed according to the provisional ICS method for definition of obstruction [2]. The mean modal volume in group 1 was 148 (range 75–225) ml. After filling the patients to this volume, the amount of fluid voided was 21 ± 5 (SEM) % higher, indicating that the residual volume after the free flow and (or) diuresis during preparation were underestimated.

Study group 2, in which the measurements at the modal volume followed the routine urodynamic examination, comprised 12 patients. Their mean age was 47 (range 26–63) years. Eight patients demonstrated stress incontinence. Instability was found in three patients. No one was obstructed. The modal volume in group 2 averaged 178 (range 100–250) ml. This was not significantly different from the modal volume in group 1 ($P = 0.06$ in the unpaired *t* test). On average, voiding took place very close to the modal volume: the initial volume was only 1 ± 2% larger. As a consequence, the initial volumes in the voidings near the modal volume were very similar in both groups ($P = 0.94$ in the unpaired *t* test).

The values of the voiding parameters studied at cystometric capacity in the two groups are summarised in the second column of Tables 1 and 2. It was found that the only parameters showing a significant difference between the two groups were the initial bladder volume ($P = 0.019$) and the voided volume ($P = 0.015$). A comparison of the voiding parameters at the two volumes studied in both groups is given in the same two tables. It can be seen that Q_{max} was significantly smaller at the small initial volume in both groups, while the urethral resistance parameter URA (which is based on Q_{max} and $p_{det.Qmax}$) was significantly higher. Differences found between other parameter values in group 1 were not confirmed in group 2. As a special example, it can be seen that the difference between the w_{max} values at the two initial volumes was close to the level of significance in both groups. Whereas w_{max} was larger at the small volume in group 1, it was at capacity in group 2. This suggests that these parameters did not primarily depend on the initial bladder volume, but on the order of the measurements. Analysis of variance, the results of which are listed in Table 3, supported this hypothesis. The table shows that the initial bladder volume and the rank number of the measurement affected some parameter values in our study.

Discussion

Voiding parameters measured during AM have been compared with those measured during CMG in many

Table 1 Voiding parameters in Group 1, in which the measurements at approximately the modal volume preceded those at capacity. Parameter values are given as mean ± standard error of the mean

	At 1.2 × modal volume	At cystometric capacity	P
Initial volume (ml)	179 ± 12	462 ± 22	< 0.0005
Voided volume (ml)	175 ± 12	451 ± 22	< 0.0005
Residual volume (ml)	4 ± 2	10 ± 3	0.002
Q_{max} (ml/s)	13.8 ± 0.7	21.6 ± 1.5	< 0.0005
$p_{det.Qmax}$ (cm H_2O)	29.0 ± 1.8	24.6 ± 1.5	0.003
URA (cm H_2O)	14.5 ± 0.8	9.8 ± 0.6	< 0.0005
$p_{low.ave}$ (cm H_2O)	24.0 ± 1.8	20.0 ± 1.5	0.007
s_{low} (cm H_2O/ml/s)	0.91 ± 0.13	0.49 ± 0.06	0.004
w_{max} (W/m^2)	12.3 ± 0.7	10.7 ± 0.9	0.061
w_{Qmax} (W/m^2)	10.0 ± 0.6	7.6 ± 0.5	< 0.0005

Table 2 Voiding parameters in Group 2, in which the measurements at the modal volume were done after one or two at capacity. Parameter values are given as mean ± standard error of the mean

	At 1.0 × modal volume	At cystometric capacity	*P*
Initial volume (ml)	181 ± 14	572 ± 42	< 0.0005
Voided volume (ml)	164 ± 16	566 ± 42	< 0.0005
Residual volume (ml)	17 ± 5	6 ± 3	0.020
Q_{max} (ml/s)	11.4 ± 1.2	26.2 ± 2.3	< 0.0005
$p_{det.Qmax}$ (cm H_2O)	25.2 ± 3.2	29.8 ± 3.4	0.188
URA (cm H_2O)	14.0 ± 1.1	9.3 ± 0.9	0.001
$p_{low.ave}$ (cm H_2O)	18.2 ± 2.2	22.4 ± 2.7	0.069
s_{low} (cm H_2O/ml/s)	1.23 ± 0.26	0.72 ± 0.18	0.137
w_{max} (W/m^2)	9.7 ± 1.6	12.6 ± 1.0	0.042
w_{Qmax} (W/m^2)	8.3 ± 1.5	9.6 ± 0.8	0.349

Table 3 Significance levels of the dependence of the voiding parameters on the variables 'initial bladder volume' and 'rank number of the measurement' as determined with analysis of variance

	Initial volume	Rank number
Q_{max} (ml/s)	< 0.0005	0.033
$p_{det.Qmax}$ (cm H_2O)	0.966	0.070
URA (cm H_2O)	< 0.0005	0.981
$p_{low.ave}$ (cm H_2O)	0.943	0.070
s_{low} (cm H_2O/ml/s)	0.003	0.764
w_{max} (W/m^2)	0.567	0.054
w_{Qmax} (W/m^2)	0.557	0.031

studies [1, 7]. In most of these, the initial bladder volumes were significantly different. In order to test the hypothesis that the observed differences between AM and CMG can be explained from differences in the voided volume, the present study compared CMG voidings of females at the most frequently voided volume of the patient with voidings at maximum cystometric capacity. In addition, the influence of the order in which the measurements were done was examined. The residuals in all measurements did not exceed 50 ml, so that the included patients voided effectively according to criteria common in urological practice.

In most studies comparing AM and CMG voidings it is found that the initial bladder volume is smaller in AM, while the flow rate and the voiding pressure are higher [10, 7, 1]. In our study, the maximum flow rate was considerably smaller at the smaller volume, which is in accordance with the well-known volume dependence of this parameter [6, 13, 15]. The detrusor pressure at maximum flow rate was not volume dependent. This dissimilarity makes the urethral resistance parameters URA and s_{low}, which are based on flow rate and detrusor pressure values, less suitable for this study. Neither the urethral resistance parameter $p_{low.ave}$ nor the bladder contraction strength parameters w_{max} and w_{Qmax} depended on the initial bladder volume. These results indicate that the reported differences between AM and CMG voidings cannot simply be explained by differences in the voided volume. This conclusion is in agreement with the work of Webb et al. [18, 19] and Rosario et al. [11], who compared AM and CMG voidings at similar volumes, although the results of these groups of authors were not identical. Webb et al. found a higher flow rate as well as higher voiding pressures in AM, while Rosario et al. found a higher flow rate but similar voiding pressures.

The urethral resistance parameter $p_{low.ave}$ was smaller in subsequent measurements than in the first one. The difference was nearly significant. This result is in line with that of other authors [12, 5, 14]. It has been hypothesised that the apparent decrease in urethral resistance is caused by a better pelvic floor relaxation on repeated voidings [14]. If this were correct, it seems reasonable to assume that the habituation of the patient to the unnatural circumstances for voiding during CMG is a relevant factor. This mental factor may also contribute to the differences between AM and CMG voidings and explain the above described results of Webb et al. and Rosario et al. that are compatible with the hypothesis that micturition is less inhibited in AM.

In conclusion, it was shown that differences in the voided volume do not explain the reported differences between AM and CMG voidings. There is evidence suggesting that mental factors might play a role. Standardisation of the measurements, both with respect to the initial bladder volume and the environment in which voiding takes place, is necessary for a proper comparison between ambulant and conventional cystometry.

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