Bladder Contractility and Idiopathic Detrusor Instability in Males

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Thirty males (mean age 54 ± 13 years) with an "idiopathic" detrusor instability and fully compensated bladders (no post-micturition residuals) were assessed urodynamically at a short distance of time (3 months, on average) from the beginning of clinical symptoms. Thirty age-matched controls were also investigated. Detrusor shortening velocity was found to be increased in the unstable patients ($P < 0.001$), which seemed to derive from enhanced contractile capability in the presence of normal urethral resistance. Such data confirm the results of previous investigations in males with obstructive detrusor instability as well as in women with idiopathic unstable bladders. The significance of these findings was discussed. In particular, it was suggested that detrusor instability may involve changes leading both to more excitable bladder smooth muscle cells and to an easier electrical coupling between the same cells, thus, to enhanced contractile capability. It was also suggested that if an impaired contractile function in unstable bladders may be the final result of a process of detrusor collagenosis, increased bladder contractility would rather characterize an initial phase in the natural history of detrusor instability.

Key words: detrusor instability, bladder contractility, voiding mechanics

INTRODUCTION

Though denied by some authors [Groen et al., 1991], the possibility of a relationship between increased bladder contractility and an overactive detrusor function seems rather difficult to be excluded. Evidence for such a link was actually provided in patients with detrusor hyperreflexia [Perkash and Wolfe, 1991], and this seemed also the case for males with detrusor instability (DI) from prostatic obstruction [Cucchi, 1990, 1991, 1992] as well as for women with idiopathic DI [Cucchi, 1993]. The aim of this study was now to ascertain whether detrusor contractility differs in males, also between patients with idiopathic DI and age-matched controls. A series of general considerations about the reasons for and the significance of a possible relationship between DI and an increased bladder contractile capability could also be made.

PATIENTS AND METHODS

Thirty patients aged 54 ± 13 years (group A) were chosen randomly out of a group of about 60 males with an idiopathic DI. They had been referred to our unit for...
urgency of micturition (or even urge incontinence), frequency, and nocturia. Symptoms had been present for a mean of 3 months (range: 1–7 months) prior to our examination. DI, as defined according to the International Continence Society [Abrams et al., 1988], could be ascertained urodynamically in all subjects. Clinical assessment comprised symptom analysis, physical examination, spontaneous free flow uroflowmetry, and sitting medium fill water cystometry with pressure flow study. Synchronous needle electrode electromyographic recordings were done in selected cases. The patients had urinalysis and urine culture prior to urodynamics, as well as cystourethrography and cystoscopy at later dates. Bladder biopsies were also performed in selected cases.

Cystometry was carried out infusing 0.9% saline at room temperature via an 8F Nélaton transurethral catheter. A 16F rectal balloon catheter inflated with 10 ml saline measured abdominal pressure (p_{ab}), intra-vesical pressure (p_{ve}), being recorded through a 5F Nélaton transurethral catheter. Both pressure-measuring catheters were connected through fluid-filled lines to external strain gauge transducers mounted on a stand at the level of the patient’s symphysis pubis. Electronic subtraction of p_{ab} from p_{ve} gave detrusor pressure (p_{det}). During cystometry, care was taken to note the occurrence of unstable (phasic involuntary) detrusor contractions. When no such contractions were seen, the bladder was stressed by provocation tests including changing of posture, more rapid filling, coughing, etc. At maximum cystometric capacity (MCC) the 8F catheter was removed and a pressure flow study was done, urine flow rate being measured by the same weight flowmeter used for spontaneous free flow uroflowmetry. Post-micturition residuals were measured by catheterization.

Both pressure and flow signals were recorded on a paper strip chart recorder as well as digitized and subsequently analyzed by a computer. Analog-to-digital conversion was performed during on-line data acquisition with a 10 Hz sampling frequency and 12 bit resolution. The same signals were synchronized with a correction of 0.7 s for the delay in flow rate measurement and processed after low pass digital filtering.

No definable causes of DI could be found in group A. In particular, bladder outflow obstruction (BOO) was excluded at pressure flow study according to the criteria of Abrams and Griffiths [1979]. Neurological or mental diseases were also excluded, along with metabolic disturbances, interstitial cystitis, bladder stones or neoplasms, urinary tract infections, or any other causes that could directly or indirectly affect detrusor function. None of the subjects investigated was undergoing treatments with any drug known to possibly interfere with the phases of bladder filling or voiding.

The control group B comprised 30 age-matched males (mean age 50 ± 13 years) referred for recurrent urinary infections (but with no signs of infection at the time of the evaluation and no pathologic findings at cystoscopy and cystourethrography). None of them had irritative bladder symptoms when examined at our unit or during the intervals between recurrences of urinary infection. These males also underwent clinical assessment and urodynamics as previously described for group A, with no abnormalities of any type being discovered.

For each patient in the 2 groups the following parameters, derived from pressure flow study, were evaluated: the MCC (in ml); the bladder volume voided as well as the post-micturition residual (both in ml); the peak flow pressure, p_{det \ Q_{max}} (in cm
H₂O); the peak flow rate, \( Q_{\text{max}} \) (in ml/s). In order to find a volume-independent parameter allowing comparisons of peak flow, \( Q_{\text{max}} \) was divided by the square root of the total bladder volume, \( V \) (= volume voided + residual urine, in ml), the resulting index (\( cQ_{\text{max,}} \) in \( \sqrt{\text{ml/s}} \)) representing the peak flow corrected according to the relation of \( Q_{\text{max}} \) proportional to \( V^{0.5} \) [von Garrelts, 1957].

The contractility parameters \( WF_{\text{max}} \) [Griffiths et al., 1986] and \( dl/dt_{40} \) [Rollema et al., 1977; Rollema and Griffiths, 1984; Rollema, 1991] were also computed. \( WF_{\text{max}} \) (in \( \mu \text{W/mm}^2 \)) is an approximation to the maximum mechanical power (per unit of bladder wall surface area) generated by the contracting detrusor during voiding, while \( dl/dt_{40} \) (in mm/s) equals the shortening velocity of the contracting detrusor as determined at a bladder volume of 40 ml before the end of micturition. This latter parameter is a close approximation to the maximum value of detrusor contraction speed, which is normally achieved near the end of voiding. According to Rollema et al. [1977], the initial bladder volume has almost no influence on the maximum value of detrusor contraction speed, except possibly for very large volumes. These were not seen in the males studied here, however. Moreover, no patient showed post-micturition residuals, and flow proved continuous in all cases. All such conditions evidently allow safe and reliable comparisons of bladder contraction speed in different subjects.

The urethral resistance factor URA (intersection of quadratic urethral resistance relation with pressure axis of pressure flow plot, in cm H₂O) was calculated according to Griffiths et al. [1989]. Patients were discarded who had URA levels of > 29 cm H₂O, this being the discrimination value for BOO according to a number of studies [van Mastrigt, 1990].

The energy expended by the detrusor per unit of bladder volume voided (e, in mJ/ml) was also measured, which is known to increase with obstruction. Such a parameter has been determined by integrating the pressure volume loop obtained during the emptying phase [Abrams et al., 1977] and dividing the result by the volume voided.

For each patient more than one filling and voiding cycles were usually recorded, and for each parameter the median of individual values recorded during different examinations was considered for analysis. Those subjects who began micturition from a state in which the detrusor pressure was already high due to an unstable contraction did not enter the study. Voiding was always initiated voluntarily in all subjects. Pseudodyssynergic voiding patterns (i.e., when the opening pressure was higher than the pressure at the end flow or even at peak flow) were also discarded. In those cases, the pressure flow study was repeated after inviting the patient to fully relax before starting micturition, which always resulted in synergetic voidings.

Student’s t-test and Wilcoxon’s rank sum test were used to check for statistical significance of differences in the 2 groups, A and B, with respect to the patients’ mean ages as well as the urodynamic parameters investigated. Results were considered significant at \( P < 0.05 \). Methods, definitions, and units conformed to the standards proposed by the International Continence Society [Abrams et al., 1988], except when specifically noted. Detrusor trabeculation, as assessed by cystoscopy as well as cystography, has been graded on the basis of an arbitrary 3-point scale (mild, moderate, or severe) according to the view that the more severe the trabeculation the greater the degree of collagenosis within the bladder smooth muscle [Gosling and Dixon, 1983].
TABLE I. Averages, Standard Deviations, and Significant Levels of Difference (by Student’s t and Wilcoxon’s Rank Sum Tests) of Various Urodynamic Parameters Derived From Pressure Flow Study in Groups A (Unstable, n = 30) and B (Stable, n = 30)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A</th>
<th>Group B</th>
<th>P values*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCC (ml)</td>
<td>285 ± 116</td>
<td>396 ± 97</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>p_{det} Q_{max} (cm H_{2}O)</td>
<td>43 ± 9</td>
<td>43 ± 7</td>
<td>n.s.</td>
</tr>
<tr>
<td>Q_{max} (ml/s)</td>
<td>14 ± 4</td>
<td>13 ± 4</td>
<td>n.s.</td>
</tr>
<tr>
<td>eQ_{max} (V ml/s)</td>
<td>0.87 ± 0.22</td>
<td>0.69 ± 0.16</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>WF_{max} (µW/mm²)</td>
<td>10.9 ± 2.9</td>
<td>10.7 ± 3.2</td>
<td>n.s.</td>
</tr>
<tr>
<td>dl/dt_{dtt} (mm/s)</td>
<td>34 ± 16</td>
<td>11 ± 4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>URA (cm H_{2}O)</td>
<td>18 ± 3</td>
<td>19 ± 3</td>
<td>n.s.</td>
</tr>
<tr>
<td>e (mJ/ml)</td>
<td>4.3 ± 1.3</td>
<td>4.3 ± 0.6</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

*Student’s t-test and Wilcoxon’s rank sum test yielded the same P values.

RESULTS

Patients’ mean ages did not differ significantly in the 2 groups. No one of the subjects investigated had post-micturition residuals, and cystoscopy and cystourethrography showed no pathologic findings, except for mild to moderate detrusor trabeculation in the unstable patients. Urinalysis and urine culture were normal. A certain degree of bladder hypersensitivity was found at cystometry in group A, i.e., the first desire to void was felt rather early, at a mean volume of 82 ± 32 ml (vs. 150 ± 31 in group B). Group A also had a mildly reduced bladder compliance (29 ± 6 ml/cm H_{2}O vs. 42 ± 6 ml/cm H_{2}O in group B).

Various urodynamic parameters derived from pressure flow study are reported in Table I. Moreover, 2 sets of tracings describe some urodynamic measurements in 2 males, with patient 1 (Fig. 1A–D) showing an unstable bladder and patient 2 (Fig. 2A–D) being a control. Maximum cystometric capacity was lower in the unstable patients. Maximum flow rate did not differ significantly in the 2 groups, but proved higher in the unstable males when corrected for the total bladder volume. The parameter dl/dt_{max}, too, proved to be higher in the unstable group A. Voiding pressures did not differ significantly between stable and unstable males, which was also the case for the maximum contraction power, the urethral resistance factor URA, and the energy expended by the detrusor per unit of bladder volume voided.

DISCUSSION

Bladder contractile capability was repeatedly found by this author to be increased in patients with DI. This was first the case for obstructive DI from benign prostatic hypertrophy [Cucchi, 1990, 1991, 1992], which has been deemed to result from denervation supersensitivity (DS) of the detrusor. Enhanced bladder contractile function was found also in females with idiopathic DI [Cucchi, 1993], and a higher degree of contractility could now be discovered even in a series of males with idiopathic DI as compared with a group of apparently normal age-matched subjects.

It is a fact that the maximum contractile power, WF_{max}, was almost the same in the 2 groups studied herein (Table I), but in the unstable group A there was a higher shortening velocity of the contracting detrusor, as reflected in higher values of dl/dt_{dtt} (Table I) and in some other data, i.e., the maximum flow rate was not reduced in the same group (Table I) despite lower filling volumes (Table I); rather, Q_{max} proved to be higher in the unstable patients when corrected for V (Table I).
Fig. 1. A: Detrusor pressure (cm H$_2$O) and flow rate (ml/s) vs. time (s) in a patient with idiopathic detrusor instability (patient 1). Some numerical values in this patient were: MCC, 264 ml; residual urine, 0 ml; $p_{\text{det}}$ at $Q_{\max}$, 41 cm H$_2$O; $Q_{\max}$, 13 ml/s; $cQ_{\max}$, 0.80 V ml/s; $W_{\text{fmax}}$, 10.8 W/m$^2$; $dV/dt_{\text{max}}$, 23 mm/s; URA, 19 cm H$_2$O; $c$, 4.0 ml/ml. B: x-y plot of detrusor pressure vs. flow rate in patient 1. C: $WF$ (W/m$^2$) vs. bladder volume (ml) in patient 1. D: Detrusor pressure and flow rate vs. bladder volume in patient 1.
Fig. 2. A: Detrusor pressure (cm H₂O) and flow rate (ml/s) vs. time (s) in a control (patient 2). Some numerical values in this patient were: MCC, 371 ml; residual urine, 0 ml; pdet at Q_max, 44 cm H₂O; Q_max, 11 ml/s; cQ_max, 0.57 ml/s; WF_max, 8.8 W/m²; d/dt, 14 mm/s; URA, 22 cm H₂O; c, 4.0 ml/ml. B: x-y plot of detrusor pressure vs. flow rate in patient 2. C: WF (W/m²) vs. bladder volume (ml) in patient 2. D: Detrusor pressure and flow rate vs. bladder volume in patient 2.
This enhanced shortening velocity of the detrusor occurred probably as a result of increased contractile capability in the presence of normal urethral resistance. Indeed, if there is a normal, relaxed urethra, a strong bladder contraction yields a high contraction speed rather than a high contraction strength [Griffiths, 1991]. BOO was actually excluded in that the urethral resistance factor URA [Griffiths et al., 1989] was in a range of normality [van Mastrigt, 1990] in all subjects. Neither did the same factor, nor the energy expended by the detrusor per unit of bladder volume voided, differ significantly between stable and unstable males (Table I). In addition, no patient had pseudodysynergic voiding patterns at pressure flow study, nor did external urethral sphincter EMG tracings show a greater discharge either at the onset or during the course of micturition. The present fact, that the urethral resistance did not differ significantly between groups A and B, would also explain why similar values of voiding pressure and maximum contractile power were discovered (Table I).

As to the main finding described hereby, that bladder reflex and contractile function were altered in group A in parallel fashion, this could suggest, along with previous results [Cucchi, 1990, 1991, 1992, 1993], that DI always involves changes leading both to more excitable bladder smooth muscle cells and to an easier coupling between the same cells, thus, to enhanced contractile capability. (At least, this might be the case provided that there is no heavy detrusor collagenosis, as probably in this series, which would be inferred by the fact that only a mild to moderate bladder trabeculation was found [Gosling and Dixon, 1983].)

One example of changes yielding a better electrical coupling is an increased number of nexal contacts between smooth muscle cells, as described in DS [Westfall, 1981], which results in an easier spread of the depolarization wave. In the absence of factors allowing for DS (such as, e.g., BOO [Speakman et al., 1987]), a neurological device has been hypothesized [Kinder and Mundy, 1987] that would reduce a tonic inhibitory or modulatory effect on detrusor reflex. Finally, a highly suggestive link was found by Elbadawi et al. [1990, 1993] between DI and newly acquired protrusion/abutment contacts, which, too, would favour a better electrical coupling.

Changes like these would possibly account for the results described in the present report as well as for similar data given in previous works [Cucchi, 1990, 1991, 1992, 1993]. Thus, urodynamic evidence for increased detrusor contractility in unstable bladders could be provided with theoretical support.

It must eventually be emphasized that enhanced detrusor contractility was found in group A at a short distance of time (3 months, on average) from the beginning of clinical symptoms. Thus, if impaired contractile function in unstable bladders may be the final result of a process of detrusor collagenosis [Resnick and Yalla, 1987], increased bladder contractile capability seems rather to characterize a very initial phase in the natural history of DI.

REFERENCES


EDITORIAL COMMENT

BLADDER CONTRACTILITY AND IDIOPATHIC DETRUSOR INSTABILITY IN MALES

Dr. Cucchi’s measurements show that there is a difference in voiding function between stable and unstable bladders in this male patient population. This is an important observation. However, the conclusions he has drawn are not entirely correct.
The variable that shows by far the most striking difference between stable and unstable bladders is $dl/dt_{40}$ which reflects the flow rate near the end of voiding. What this difference implies is that unstable bladders generate higher flow rates near the end of voiding. If detrusor contractile capability was enhanced at all bladder volumes, the contractile power $WF_{max}$ would be larger in unstable bladders. As this is apparently not so, it seems that in stable bladders the detrusor contraction is less well sustained until the end of voiding. To a certain extent this is hinted at by Figure 2D, where the flow rate fluctuates and drops rather precipitously near the end of voiding (compare the smoother curve in Figure 1D). It would be interesting to see similar tracings in other patients.

The argument presented in the paper, that the maximum contractile power $WF_{max}$ is similar in unstable and stable cases because the enhanced contractile capability of unstable bladders is manifested as a higher shortening velocity rather than a higher detrusor pressure, is incorrect. The contractile power $WF$ depends on shortening velocity as well as detrusor pressure; an increased shortening velocity would lead to an increase in $WF$, even if the detrusor pressure were unchanged.

It is interesting that no significant difference between stable and unstable bladders was seen in any variable derived from the detrusor pressure. This means that the results could be checked from noninvasive free flow measurements, once detrusor instability or stability had been established.

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AUTHOR'S REPLY

BLADDER CONTRACTILITY ANDIDIOPATHIC DETRUSOR INSTABILITY IN MALES

I do agree with Dr. Griffiths that, seemingly, compared to unstable bladders, "in stable bladders the detrusor contraction is less well sustained until the end of voiding." As I put it, detrusor instability would always involve "changes leading both to more excitable bladder smooth muscle cells and to an easier electrical coupling between the same cells." It might be this easier coupling that causes detrusor contractions to be more well sustained in unstable bladders until the end of voiding.

The argument presented, that the maximum contractile power $WF_{max}$ is similar in the 2 groups because the enhanced contractile capability of unstable bladders is manifested as a higher shortening velocity rather than a higher detrusor pressure, does not seem so incorrect. Indeed, the shortening velocity considered in the text is that attained by the detrusor near the end of voiding ($dl/dt_{40}$), which is a close approximation to the maximum bladder contraction speed, which is not necessarily equal to the shortening velocity attained at $WF_{max}$, and which, therefore, may not be reflected by such a parameter.

Should noninvasive free flow uroflowmetry offer different information about bladder contractility in stable vs. unstable bladders, it might even go so far as to offer information sufficient to identify detrusor instability.

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