EVALUATION OF DETRUSOR ACTIVITY DURING MICTURITION IN PATIENTS WITH BENIGN PROSTATIC ENLARGEMENT WITH A CLINICAL NOMOGRAM

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ABSTRACT

Purpose: We investigated the accuracy of analysis of detrusor contraction during micturition with a simple to use pressure-flow nomogram (linear passive urethral resistance relation). The computer derived maximum detrusor contraction parameter was used as a reference. The correlation with bladder emptying capability was used as a control.

Materials and Methods: Advanced pressure-flow analysis was performed in 224 elderly men with lower urinary tract symptoms with lower urinary tract symptoms bladder outlet obstruction. In the individual elderly man with an enlarged prostate and lower urinary tract symptoms bladder outlet obstruction and detrusor underactivity can be responsible for emptying, which is the reason for the addition of the phrase "...in the absence of obstruction..." in the International Continence Society definitions in regard to detrusor activity. Furthermore, the International Continence Society states that "A normal detrusor contraction will effect complete bladder emptying in the absence of obstruction." Clinically, these definitions can be interpreted as indicating that "a good -voluntary- contraction empties the bladder" and, therefore, post-void residual urine is an important parameter in the evaluation of detrusor activity during micturition. In the individual elderly man with an enlarged prostate and lower urinary tract symptoms bladder outlet obstruction and detrusor underactivity can be responsible for ineffective emptying, which is the reason for the addition of the phrase "...in the absence of obstruction..." in the International Continence Society definitions in regard to detrusor activity. Nevertheless, contractility has been quantified in clinical studies without regarding the outlet properties.

Conclusions: The nomogram is useful in the selection of patients with a good detrusor contraction. Efect complete bladder emptying in the absence of obstruction... our study confirmed the conclusion of others that the result of the micturition may be ineffective despite good initial contraction.

Key Words: urination disorders, prostatic hypertrophy, urodynamics

Although therapy to improve detrusor contractility currently is not available, the diagnosis of impaired detrusor contractility, which is detrusor underactivity in International Continence Society terminology, has a role in the therapy of patients with lower urinary tract dysfunction. By International Continence Society definition, detrusor underactivity is diagnosed when the detrusor contraction during voluntary initiated micturition is "...of inadequate magnitude and/or duration, to effect bladder emptying with a normal time span...". Furthermore, the International Continence Society states that "A normal detrusor contraction will effect complete bladder emptying in the absence of obstruction." Clinically, these definitions can be interpreted as indicating that "a good -voluntary- contraction empties the bladder" and, therefore, post-void residual urine is an important parameter in the evaluation of detrusor activity during micturition. In the individual elderly man with an enlarged prostate and lower urinary tract symptoms bladder outlet obstruction and detrusor underactivity can be responsible for ineffective emptying, which is the reason for the addition of the phrase "...in the absence of obstruction..." in the International Continence Society definitions in regard to detrusor activity. Nevertheless, contractility has been quantified in clinical studies without regarding the outlet properties.

We recently proposed bladder outlet related reference values for 1 of the methods to evaluate detrusor contraction in relation to bladder emptying. The study was based on the conviction that a contraction that empties the bladder when bladder outlet obstruction exists is of good quality. We concluded that the maximum detrusor contraction, as determined by the maximum detrusor working function, in patients with bladder outlet obstruction was increased, and emptying efficacy was preserved in many patients. In other patients the efficiency of emptying was hampered by early decay of contraction. Our study confirmed the conclusion of others that the result of the micturition may be ineffective despite good initial contraction.

In animal models it is observed that bladder outlet obstruction causes changes in anatomy and function of the detrusor muscle. In biopsies of human detrusor muscle changes are described due to aging and possibly bladder outlet obstruction, and related to impairment of detrusor activity during micturition. Changes in detrusor histology are assumed to reflect changes in muscle function. However, the in vivo function of the human detrusor is scarcely understood.

Several parameters to quantify detrusor activity during micturition have been used, including maximum detrusor pressure, detrusor pressure at maximum flow, maximum isovolumic contraction and maximum force and/or velocity based on the Hill equation. Traditionally, urodynamic diagnosis of detrusor activity is determined by observation of maximum detrusor or intravesical pressure during micturition. However, maximum detrusor pressure as a solitary parameter cannot completely quantify detrusor activity. A good method to quantify muscle contraction force in a laboratory setting is to measure maximum isometric contraction. Stop flow testing was used to quantify detrusor activity during urodynamic investigation, based on the assumption that the detrusor is forced to a maximum of isovolumic (isometric) contraction by interruption of flow so that the maximum isovolumic contraction could be observed. The predictive value of this test regarding the outcome of prostatectomy is low. Besides practical difficulties that hamper the use of this test, in patients with bladder outlet obstruction the pressure increase when the flow is interrupted can at best be moderate (as observed previously) because the contraction...
of the detrusor is already nearly at maximum force and minimum velocity due to the increased outlet resistance.\textsuperscript{14,24}

The relationship of force and velocity, as obtained in a laboratory setting during muscle strip testing, is described by a hyperbolic force-velocity curve (the Hill curve).\textsuperscript{18} The pressure and flow curves can be combined and displayed in such a way that a micturition force-velocity graph is generated, and a bladder working function can be used to quantify detrusor contraction force and detrusor contraction velocity on this graph.\textsuperscript{20,22} However, besides force and velocity, endurance or contractation may be important.\textsuperscript{26,27}

The detrusor working function is another method to display the work of the detrusor on a graph showing the product of force and velocity at any (volume related) moment during the entire course of micturition.\textsuperscript{21,28} The detrusor working function curve enables quantification of the maximum of detrusor work (maximum detrusor contraction), which is the maximum of the detrusor working function curve. We used bladder outlet obstruction related maximum detrusor contraction reference values to qualify the detrusor activity of every micturition (table 1).\textsuperscript{14} At values less than these the contraction is considered low, while higher values indicate a good contraction.

All of the aforementioned methods require mathematical data conversion by computer. The linear passive urethral resistance relation is a nomogram that provides a method to qualify detrusor contraction without a computer. It provides clinically relevant grading of bladder outlet obstruction, consistent with intra-assay variability of the pressure-flow relationship.\textsuperscript{29,30} In combination with grading of bladder outlet obstruction, the nomogram enables grading of detrusor contraction. The 4 grades of detrusor contraction strength are very weak, weak, normal and strong.\textsuperscript{23,29} The borderlines of these grades are based on Hill contraction analysis curves as described. These lines are developed via conceptual and clinical outcome techniques.\textsuperscript{23} The allocation to 1 of the contraction classes is determined by the position of the point of detrusor pressure at maximum flow on the graph.

Urodynamic analysis of bladder outlet obstruction is quantified by linear passive urethral resistance relation obstruction classes.\textsuperscript{29} Furthermore, analyses of bladder outlet obstruction with urethral resistance factor and passive urethral resistance relation analysis are performed. Passive urethral resistance relation analysis describes the minimum voiding detrusor pressure and the theoretical cross-sectional area of the flow controlling zone.\textsuperscript{19} Urethral resistance factor is an approximation of minimum voiding pressure, derived from the point of detrusor pressure at maximum flow, and based on an average combination of minimum voiding pressure and theoretical cross-sectional area of the flow controlling zone.\textsuperscript{28} Since grading of detrusor activity is clinically important in the treatment and follow-up of patients with bladder outlet obstruction and lower urinary tract symptoms, we investigated the linear passive urethral resistance relation contraction classification in comparison to the bladder outlet obstruction related maximum detrusor contraction.

### Patients and Methods

Urodynamic investigations of 242 unselected elderly men referred to our outpatient clinic for prostatic diseases due to lower urinary tract symptoms were reviewed. All men had prostatic enlargement on clinical examination, with prostate specific antigen in the normal range and benign structure on ultrasound, and all were considered neurologically normal based on history, symptoms and physical examination. Uroflowmetry was performed using an 8F transurethral lumen catheter and an ultrasound, and all were considered neurologically normal.

Abdominal pressure was recorded intrarectally with an 8F microtip sensor catheter. The pressure sensors were set at zero according to the situation before introduction. Before voiding the bladder was emptied through the lumen of the transurethral catheter to quantify residual volume after initial voiding. After this voiding free uroflowmetry, the bladder was filled with water at 20°C and a filling speed of 50 ml. per minute with the patient supine. Filling was stopped when the patient expressed a strong urge to void. Micturition while standing was allowed in private, and the amount of post-void residual was measured again. Since the individual voided volumes and post-void residuals partially depend on the cystometric capacity, the efficiency of micturition was quantified by voiding percentage, that is the percentage of cystometric capacity voided,\textsuperscript{31} to ensure a more reliable evaluation, not dependent on storage capacity.

Detrusor contraction strength was categorized with the bladder outlet obstruction related maximum detrusor contraction (table 1). The grades of detrusor contraction strength of the linear passive urethral resistance relation nomogram were analyzed in comparison with these bladder outlet obstruction related maximum detrusor contraction categories. Furthermore, the relationship of both parameters with the voiding percentage and post-void residual was analyzed. The linear passive urethral resistance relation contraction classes were combined. Patients with normal or strong contractions on the nomogram were considered to have a good linear passive urethral resistance relation contraction, while those with weak and very weak results on the nomogram were considered to have a low linear passive urethral resistance relation contraction. Bladder outlet obstruction was evaluated with the passive urethral resistance relation curve analysis, resulting in values of minimal detrusor pressure during voiding and theoretical flow controlling cross-sectional area.\textsuperscript{5,18} Bladder outlet obstruction was further quantified with the urethral resistance factor.\textsuperscript{28}

Differences between mean parameter values were tested with a paired samples t-test when appropriate, or with a Wilcoxon matched pairs signed-rank test. The chi-square test was used for correlation analysis. The resulting p values are provided.

### Results

Mean patient age was 64.2 years (range 47 to 84) and mean prostate volume plus or minus standard deviation was 43.5 ± 29.5 cm\textsuperscript{3} (range 22 to 160). The prostate was smaller than 30 cm\textsuperscript{3} in 54 patients (22.1%), although it was considered enlarged during clinical examination. Average International Prostatic Symptom Score for these patients was 16.7 (range 8 to 33), and 39 had moderate or severe bladder outlet obstruction. Average International Prostatic Symptom Score for all patients was 18.6 (range 4 to 35). Table 2 shows the results of the urodynamic analysis for the total group. Figure 1 gives the number of patients in various subgroups. Bladder outlet obstruction was diagnosed according to urethral resistance factor (more than 28 cm\textsuperscript{2} water) in 156 patients (64.5%) and according to linear passive urethral resistance relation (class more than 2) in 140 (57.8%). According to linear pas-

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Linear Passive Urethral Resistance Relation Class of Obstruction</th>
<th>Lower Limit of Good Bladder Outlet Obstruction</th>
<th>Related Maximum Detrusor Contraction (W m\textsuperscript{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>9.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>
DETRUSOR ACTIVITY DURING MICTURITION AND BENIGN PROSTATIC ENLARGEMENT

Table 2. Mean parameters of urodynamic investigation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detrusor pressure (cm. water)</td>
<td></td>
</tr>
<tr>
<td>Start of filling</td>
<td>16.6 ± 10.6</td>
</tr>
<tr>
<td>End of filling</td>
<td>37.4 ± 22.0</td>
</tr>
<tr>
<td>Capacity (ml.)</td>
<td>395 ± 146</td>
</tr>
<tr>
<td>Voided vol. (ml.)</td>
<td>287 ± 137</td>
</tr>
<tr>
<td>Post-void residual (ml.)</td>
<td>107 ± 137</td>
</tr>
<tr>
<td>Voided % of capacity</td>
<td>73.2 ± 28.5</td>
</tr>
<tr>
<td>Maximum flow (ml/sec.)</td>
<td>7.7 ± 4.1</td>
</tr>
<tr>
<td>Detrusor pressure at maximum flow (cm. water)</td>
<td>64.0 ± 27.8</td>
</tr>
<tr>
<td>Minimum voiding pressure (cm. water)</td>
<td>33.4 ± 19.4</td>
</tr>
<tr>
<td>Theoretical cross-sectional area of flow controlling zone (mm.²)</td>
<td>3.9 ± 2.62</td>
</tr>
<tr>
<td>Urethral resistance factor (cm. water)</td>
<td>38.4 ± 18.5</td>
</tr>
<tr>
<td>Maximum detrusor contraction (W/m²)</td>
<td>12.0 ± 5.8</td>
</tr>
</tbody>
</table>

Table 3. Number and percents of patients in linear passive urethral resistance relation and bladder outlet obstruction related maximum detrusor contraction classes in comparison with percent relative volume and post-void residual

<table>
<thead>
<tr>
<th>Total No. Pts.</th>
<th>Linear Passive Urethral Resistance Relation Contraction</th>
<th>Bladder Outlet Obstruction Related Maximum Detrusor Contraction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Relative voided vol.:</td>
<td>Low</td>
<td>Good</td>
</tr>
<tr>
<td>Less than 75</td>
<td>107</td>
<td>56 (23.5)</td>
</tr>
<tr>
<td>More than 75</td>
<td>131</td>
<td>62 (26.1)</td>
</tr>
<tr>
<td>Totals</td>
<td>238</td>
<td>118†</td>
</tr>
<tr>
<td>Post-void residual (ml.):</td>
<td>Low</td>
<td>Good</td>
</tr>
<tr>
<td>More than 50</td>
<td>149</td>
<td>80 (33.1)</td>
</tr>
<tr>
<td>Less than 50</td>
<td>93</td>
<td>58 (15.7)</td>
</tr>
<tr>
<td>Totals</td>
<td>242</td>
<td>146‡</td>
</tr>
</tbody>
</table>

* Chi-square p = 0.000.
† Chi-square p = 0.442.
‡ Chi-square p = 0.052.

chi-square p = 0.000.

there is almost complete agreement of the linear passive urethral resistance relation method with maximum detrusor contraction in patients with a good contraction, especially those without or with moderate bladder outlet obstruction. On the other hand, more than 50% of all patients with a contraction considered low on linear passive urethral resistance relation analysis had a good maximum detrusor contraction. The number of patients without bladder outlet obstruction whose linear passive urethral resistance relation contraction was low correlated highly with a good maximum detrusor contraction (40.2%). Almost 50% of the patients in this subgroup with a low linear passive urethral resistance relation contraction demonstrated a good maximum detrusor contraction. The urodynamic results of the maximum detrusor contraction subgroups (good and low) with a low linear passive urethral resistance relation contraction are shown in table 6. In the patients with a good bladder outlet obstruction related maximum detrusor contraction the voiding percentage and post-void residual indicated better emptying compared to those with a low maximum detrusor contraction. Furthermore, bladder contents emptied before the moment of maximum detrusor contraction were greater (voided volume and voiding percentage at maximum detrusor contraction), indicating a better initial phase of micturition and suggesting that a genuine difference exists in contraction between the patients in these subgroups who are classified into 1 diagnosis group based on the linear passive urethral resistance relation nomogram.

DISCUSSION

Among our patients with a wide variation of bladder outlet obstruction, prostate size and symptoms 59.5% had a detrusor contraction during micturition that was considered normal or strong according to the linear passive urethral resistance relation classification. Almost all of these patients...
Fig. 2. Detrusor pressure at maximum flow in each case to compare both methods of contraction analysis. Lines in pressure-flow graph indicate bladder outlet obstruction and weak contraction. Cases with detrusor pressure at maximum flow above dashed line from 30 to 54 cm. water on Y axis have bladder outlet obstruction. Cases below solid line from 100 cm. water on Y axis to 20 ml. per second on X axis have weak contraction. □, patients with weak contraction according to bladder outlet obstruction related reference values for maximum detrusor contraction. Note that detrusor pressure at maximum flow is not identical to maximum detrusor contraction (WF max).

Fig. 3. Pressure-flow graphs with detrusor pressure in relation to voiding efficiency. A, detrusor pressure at maximum flow in relation to large amount of residual urine (■). B, detrusor pressure at maximum flow in relation to low voided percentage (■).

(94.4%) also had a good contraction according to the computer obtained bladder outlet obstruction related maximum detrusor contraction value. Figure 2 shows the results listed in table 4 regarding detrusor pressure at maximum flow (vertical axis) and maximum flow (horizontal axis) for each patient. The points are marked according to good and low bladder outlet obstruction related maximum detrusor contraction. Figure 3 shows that, although the detrusor contraction for almost all cases noted above the linear passive urethral resistance relation contraction line on the graph is
and, furthermore, there is no difference in detrusor pressure at maximum flow, minimal detrusor pressure during micturition or urethral resistance factor.

However, the slight difference in the theoretical cross-sectional area deserves mention. Theoretical cross-sectional area of flow controlling zone depicts the distensibility of the urethra. Because the detrusor is the antagonist of the outlet and drives micturition, distension of the urethra by the detrusor (at maximum flow) may influence theoretical cross-sectional area of flow controlling zone in some patients. Possibly in these patients with bladder outlet obstruction the detrusor seems incapable of opening (distending) the outlet sufficiently (and/or rapidly) enough to ensure effective micturition. Thus, the theoretical cross-sectional area of flow controlling zone may be influenced by weak detrusor contractility, although this theory remains strictly hypothetical. In the subgroup with a low linear passive urethral resistance relation contraction it is still unclear to what extent the ineffective micturition is caused by a diminished contraction or bladder outlet obstruction. Many of these patients have some bladder outlet obstruction combined with effective micturition and, therefore, the detrusor contraction must be regarded as normal despite a weak linear passive urethral resistance relation contraction.

Both classifications do not perfectly distinguish patients who are able to empty the bladder. The linear passive urethral resistance relation contraction classification is based on the point of detrusor pressure at maximum flow during micturition, whereas in the majority of patients maximum detrusor contraction represents another moment. In patients with a good contraction according to linear passive urethral resistance relation contractility this difference seems not to affect the classification. In patients with a low linear passive urethral resistance relation contraction the maximum detrusor contraction analysis provides additional information about detrusor activity during micturition. Overall, the cause of incomplete emptying depends on the individual combination of bladder outlet and detrusor contractility. We do not have the means to determine this individual combination, which perhaps also is confounded by aging of the detrusor muscle, blood vessels and/or nerves. 

More clinical studies of the cause of ineffective emptying, and the association of bladder outlet obstruction and detrusor contractility are required to provide better understanding of micturition efficiency. For instance, time related analysis of detrusor contraction could improve our fundamental understanding of the endurance of detrusor contraction. Nevertheless, outcome studies are required to demonstrate the value of refined analysis of detrusor contraction in relation to the analysis of bladder outlet obstruction.

**CONCLUSIONS**

Linear passive urethral resistance relation as well as the bladder outlet obstruction related maximum detrusor contraction do not completely and unambiguously describe bladder emptying efficiency. When bladder outlet obstruction related maximum detrusor contractions are used as the reference, the procedure of plotting the detrusor pressure at maximum flow on a nomogram provides a relatively reliable means to select patients with good detrusor activity during micturition, since essentially every patient with a linear passive urethral resistance relation above the normal contraction borderline value had a good bladder outlet obstruction related maximum detrusor contraction as well. However, 50% of the patients with a weak linear passive urethral resistance relation contraction had a good bladder outlet obstruction related maximum detrusor contraction. On average, this subgroup of patients had effective micturition despite bladder outlet obstruction. Therefore, patients with a weak linear passive urethral resistance relation contraction require additional analysis of the detrusor contraction.

### Table 4. Number of patients in bladder outlet obstruction related maximum detrusor contraction classes in comparison with linear passive urethral resistance relation classes

<table>
<thead>
<tr>
<th>Bladder Outlet Obstruction Related Maximum Detrusor Contraction</th>
<th>No. Pts. With Linear Passive Urethral Resistance Relation Contraction (%)</th>
<th>Low</th>
<th>Good</th>
<th>% Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>57 (23.8)</td>
<td>7 (2.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>61 (26.2)</td>
<td>117 (48.3)</td>
<td></td>
<td>72.9</td>
</tr>
</tbody>
</table>

### Table 5. Number of patients in bladder outlet obstruction related maximum detrusor contraction classes in comparison with linear passive urethral resistance relation classes of 2 or less (no or moderate obstruction)

<table>
<thead>
<tr>
<th>Bladder Outlet Obstruction Related Maximum Detrusor Contraction</th>
<th>No. Pts. With Linear Passive Urethral Resistance Relation Contraction (%)</th>
<th>Low</th>
<th>Good</th>
<th>% Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>32 (31.4)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>41 (40.2)</td>
<td>29 (28.4)</td>
<td></td>
<td>59.8</td>
</tr>
</tbody>
</table>

### Table 6. Mean parameters in 118 patients with a low linear passive urethral resistance relation contraction (very weak and weak) according to good or low bladder outlet obstruction related maximum detrusor contraction

<table>
<thead>
<tr>
<th>Maximum Variables</th>
<th>Detrusor Contraction (W/m²)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total No. pts.</td>
<td>61</td>
<td>0.001</td>
</tr>
<tr>
<td>Post-void residual (ml)</td>
<td>177</td>
<td></td>
</tr>
<tr>
<td>Voided %</td>
<td>72.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Maximum flow (ml/sec)</td>
<td>60.3</td>
<td></td>
</tr>
<tr>
<td>Detrusor pressure maximum flow (cm. water)</td>
<td>5.8</td>
<td>0.031</td>
</tr>
<tr>
<td>Minimum voiding pressure (cm. water)</td>
<td>7.1</td>
<td>0.031</td>
</tr>
<tr>
<td>Urethral resistance factor (cm. water)</td>
<td>3.17</td>
<td>0.031</td>
</tr>
<tr>
<td>Theoretical cross-sectional area (mm²)</td>
<td>2.9</td>
<td>0.002</td>
</tr>
<tr>
<td>Maximum detrusor contraction (W/m²)</td>
<td>10.9</td>
<td>0.000</td>
</tr>
<tr>
<td>Voided vol. at maximum detrusor contraction (ml)</td>
<td>197</td>
<td>0.000</td>
</tr>
<tr>
<td>Voided % at maximum detrusor contraction (ml)</td>
<td>44.4</td>
<td>0.000</td>
</tr>
</tbody>
</table>

* Significance due to selection.

Considered adequate by both methods (fig. 2), many have ineffective emptying. We believe that it is acceptable to relate linear passive urethral resistance relation as well as the theoretical cross-sectional area of flow controlling zone to the distensibility of the urethra. Because the detrusor is the antagonist of the outlet and drives micturition, distension of the urethra by the detrusor (at maximum flow) may influence theoretical cross-sectional area of flow controlling zone in some patients. Possibly in these patients with bladder outlet obstruction the detrusor seems incapable of opening (distending) the outlet sufficiently (and/or rapidly) enough to ensure effective micturition. Thus, the theoretical cross-sectional area of flow controlling zone may be influenced by weak detrusor contractility, although this theory remains strictly hypothetical. In the subgroup with a low linear passive urethral resistance relation contraction it is still unclear to what extent the ineffective micturition is caused by a diminished contraction or bladder outlet obstruction. Many of these patients have some bladder outlet obstruction combined with effective micturition and, therefore, the detrusor contraction must be regarded as normal despite a weak linear passive urethral resistance relation contraction.

Both classifications do not perfectly distinguish patients who are able to empty the bladder. The linear passive urethral resistance relation contraction classification is based on the point of detrusor pressure at maximum flow during micturition, whereas in the majority of patients maximum detrusor contraction represents another moment. In patients with a good contraction according to linear passive urethral resistance relation contraction this difference seems not to affect the classification. In patients with a low linear passive urethral resistance relation contraction the maximum detrusor contraction analysis provides additional information about detrusor activity during micturition. Overall, the cause of incomplete emptying depends on the individual combination of bladder outlet and detrusor contractility. We do not have the means to determine this individual combination, which perhaps also is confounded by aging of the detrusor muscle, blood vessels and/or nerves. More clinical studies of the cause of ineffective emptying, and the association of bladder outlet obstruction and detrusor contractility are required to provide better understanding of micturition efficiency. For instance, time related analysis of detrusor contraction could improve our fundamental understanding of the endurance of detrusor contraction. Nevertheless, outcome studies are required to demonstrate the value of refined analysis of detrusor contraction in relation to the analysis of bladder outlet obstruction.
DETRUSOR ACTIVITY DURING MICTURITION AND BENIGN PROSTATIC ENLARGEMENT

and a number of respected investigators
ments for lower urinary tract symptomatology, including watchful
resistance and a consequent decrease in or cure of the symptomatol
anatomically obstructed prostate, such that ablation of the outlet
234
478
24. Schäfer, W.: Principles and clinical application of advanced uro-
10. Griffiths, D. J.: Assessment of detrusor contraction strength or rather the relevance of the data and the analysis, and I was asked to
12. Griffiths, D. J. and Scholtmeijer, R. J.: Vesicoureteral reflux and (there were only 2 methods then, transurethral resection of the
15. Andersen, J. T.: Prostatism III. Detrusor hyperreflexia and resid­
2. Castro, J. E., Griffiths, H. J. and Shackman, R.: Significance of
3. Bruskewitz, R. C., Iversen, P. and Madsen, P. 0.: Value of
51
602, 1982.
64
272, 1992.
272, 1992.

EDITORIAL COMMENT

This well written article contains accurate and well presented data. Based on limited knowledge about mathematical data conver-
mission between lower urinary tract symptomatology in older men and
anatomically obstructed prostate, such that ablation of the outlet
(two were only 1 methods then, transurethral resection of the prostate and open prostatectomy) resulted in a decrease in outlet
resistance and a consequent decrease in or cure of the symptomatology. Except for an occasional patient who never really was cured of
urinary retention, I assumed that all of the others did pretty well, since I personally saw few of them during followup. As I entered
practice I realized that, depending on the population, between 5 and
25% of these patients did not do well symptomatically or at least did
not do as well as one would have expected assuming that increased outlet resistance secondary to prostatic enlargement was the primary
problem. I was pleased and not so pleased to find that my colleagues had similar experiences. Sophisticated urodynamics then
arrived on the scene, and a number of respected investigators reported that approximately 30% or more of patients who presented
with lower urinary tract symptoms, heretofore diagnosed as having outlet obstruction, in fact did not have obstruction according to 1 or
a number of complex urodynamic categorizations, some with and some without sophisticated computer assisted, mathematical data
conversion. This finding was satisfying, since I assumed that the prostatectomy failure group and the urodynamically unobstructed group were, in fact, the same. Unfortunately, I then figured out that no one had ever really proved this to be the case.

For the last few years the urodynamic literature has been filled with various ways of analyzing pressure-flow data. In addition to this article, these data have been characterized by various parameters, such as the Abrams-Griffiths nomogram, urethral resistance factor, OBI, passive urethral resistance relation, CLIM, CHESS, and DAMPF. What do these add? The global question seems to be whether the evaluation of lower urinary tract symptoms is more likely to lead to a better treatment outcome if urodynamic studies are performed, including analyzing the results of these studies in various mathematical ways with and without computer assistance. In other words, do sophisticated (or unsophis-
ticated) urodynamic studies predict the outcome of various treatments for lower urinary tract symptomatology, including watchful
waiting? The critical question is, when considering a given analysis of pressure-flow data, are patients with lower urinary tract symp-
toms in whom outlet ablation fails the same as those whose detrusor

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not question the materials and methods, results or conclusions but,
write an editorial comment in explanation. What I meant was that
when I was a resident I assumed that there was a concrete associa-
tion between lower urinary tract symptomatology in older men and
an anatomically obstructed prostate, such that ablation of the outlet
(two were only 1 methods then, transurethral resection of the prostate and open prostatectomy) resulted in a decrease in outlet
resistance and a consequent decrease in or cure of the symptomatology. Except for an occasional patient who never really was cured of
urinary retention, I assumed that all of the others did pretty well, since I personally saw few of them during followup. As I entered
practice I realized that, depending on the population, between 5 and
25% of these patients did not do well symptomatically or at least did
not do as well as one would have expected assuming that increased outlet resistance secondary to prostatic enlargement was the primary
problem. I was pleased and not so pleased to find that my colleagues had similar experiences. Sophisticated urodynamics then
arrived on the scene, and a number of respected investigators reported that approximately 30% or more of patients who presented
with lower urinary tract symptoms, heretofore diagnosed as having outlet obstruction, in fact did not have obstruction according to 1 or
a number of complex urodynamic categorizations, some with and some without sophisticated computer assisted, mathematical data
conversion. This finding was satisfying, since I assumed that the prostatectomy failure group and the urodynamically unobstructed group were, in fact, the same. Unfortunately, I then figured out that no one had ever really proved this to be the case.

For the last few years the urodynamic literature has been filled with various ways of analyzing pressure-flow data. In addition to this article, these data have been characterized by various parameters, such as the Abrams-Griffiths nomogram, urethral resistance factor, OBI, passive urethral resistance relation, CLIM, CHESS, and DAMPF. What do these add? The global question seems to be whether the evaluation of lower urinary tract symptoms is more likely to lead to a better treatment outcome if urodynamic studies are performed, including analyzing the results of these studies in various mathematical ways with and without computer assistance. In other words, do sophisticated (or unsophis-
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contractility is judged ineffective by the criteria under consideration? If the answer to this question is no, then the relevance of the analysis is in question unless it can predict which patients will worsen or who will have undesirable sequelae, or it can predict which modalities are apt to be more successful in treatment than others. In my opinion, those who perform urodynamics have done a remarkably poor job of looking into this aspect of outcome analysis.

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REPLY BY AUTHORS

There is a lack in outcomes analysis regarding the diagnosis of weak contraction (or contractility). As we previously wrote, “Outcome studies will be necessary, indeed. It is however useless to start outcome studies with (possibly) fundamentally inappropriate methods of analysis. Testing the differences between two methods of analysis was our aim.” This and similar articles from our department attempt to compare the various methods of analysis micturition with the aforementioned parameters to clear up the confusing number of analysis methods. These comparisons may be seen as fundamental investigations and they are probably somewhat conceptual science. We assume that they are of value to the urological community and we appreciate their publication.

However, concerning outcomes analysis in our opinion it may be worthwhile to consider outcome studies not to select “patients . . . in whom outlet ablation fails” but to select those who do not immediately need resolution of obstruction. It is our conviction that all urologists would endorse a test that classified every bladder outlet as obstructed or not and every detrusor as good or bad if this test were inexpensive, simple, noninvasive and reliable with a perfect predictive value. In other words, we cannot believe that urologists disprove the various outcomes of urodynamic classification in the aforementioned categories. However, the assumption seems to exist that cost-benefit analysis of appropriate diagnoses, as is possible today, will be negative compared to a pragmatic approach. In our opinion this premise deserves testing in addition to the testing of clinical outcome in relation to the result of urodynamics.