Detrusor Blood Flow as A Measure of Bladder Outlet Obstruction in Patients with Benign Prostatic Hyperplasia

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Abstract

Objective: In patients with benign prostatic hyperplasia (BPH), detrusor blood flow was evaluated by color Doppler ultrasonography (CDU) with the aim of revealing its possible usefulness as a measure of bladder outlet obstruction (BOO).

Material and Methods: A total number of 30 men with lower urinary tract symptoms (LUTS) suggestive of BPH underwent pressure flow study (PFS) and detrusor CDU. Pulsatile blood flow was measured at three sites, i.e., anterior bladder wall and the two lateral walls, and detrusor resistive index (DRI) was calculated. The findings were compared between patients with and without BOO.

Results: Between patients with and without BOO, there were significant differences for age (69.2 vs 62.1 years, p<0.005), prostate volume (45.5 vs 34.7, p<0.05), bladder wall thickness (5.6 vs 3.2, p<0.001), blood flow detection (16/18 vs 3/12, p<0.001) and DRI (0.82 vs 0.65, p<0.005). BOO was detected with a diagnostic accuracy of 83.3% (25/30) by CDU.

Conclusions: Color Doppler ultrasonography has the promise to become a possible indicator for the diagnosis of BOO. To ascertain its clinical utility in terms of BOO predictability, a prospective study in a large cohort is needed.

Key Words: Benign prostatic hyperplasia – Detrusor blood flow – Bladder outlet obstruction.

Introduction

BLADDER outlet obstruction due to benign prostatic hyperplasia (BOO/BPH) is commonly associated with lower urinary tract symptoms (LUTS). An accurate diagnosis of BOO is required especially in cases of failed medical therapy or before surgical intervention. The diagnosis of BOO can be implied or presumed based on noninvasive studies such as uroflow and postvoid residual studies, but a precise diagnosis requires more invasive urodynamic testing [1].

Several experimental rat studies observed a significant reduction in detrusor blood flow in obstructed rat bladder compared with nonobstructed ones [2]. These studies also noted that BOO in rats is characterized by pathophysiologic changes such as muscle hypertrophy and connective tissue infiltration [3]. Likewise, Lin and Colleagues [4] used laser Doppler flowmetry to assess detrusor blood flow in New Zealand white rabbits and found a substantial decrease in the regional blood flow in obstructed compared with nonobstructed urinary bladders.

The present study was based on previous observations along with the assumption that there might be some difference in detrusor blood perfusion between patients with and without BOO/BPH. The ability of CDU of the bladder to predict BOO was tested in this study.

Material and Methods

Between January 2006 and October 2006, 30 patients with LUTS/BPH were enrolled in this study for measurement of detrusor blood flow by color Doppler ultrasonography. Their ages ranged from 54 to 72 (mean 67.5±15.1yr). No patient had received prior medication to relieve his symptoms at the time of the study. The blood flow was also measured in 10 men. Their ages ranged from 51 to 69, with a mean of 65.8±14.2yr. They had neither urinary symptoms nor past history suggestive of the presence of neurogenic bladder dysfunction or infravesical obstruction (control group).

All patients underwent basic and urologic studies, including pressure flow study (PFS), and CDU of the bladder. Detrusor resistive index was measured whenever pulsatile blood flow was detected.
The patients had no disorders suggesting the presence of neurogenic bladder dysfunction, conforming to the specified exclusion criteria of the International Scientific Committee on BPH (International Scientific Committee 1997).

Pressure flow studies were carried out in accordance with the technique and criteria developed by International Continence Society [5]. A bladder outlet obstruction index (BOOI) is represented by the equation: BOOI = Pdet @ Qmax -2Qmax. A BOOI >40 was considered compatible with the occurrence of BOO.

The measurement of detrusor blood flow and DRI was performed according to the method already described [6,7]. Transabdominal US was performed on patients in the supine position using 3.75 and 8-MHz probes (SSA-350 Toshiba, Tokyo, Japan). An oblique scan was obtained on the midline of the lower abdomen just above the symphysis pubis. The thickness of the anterior bladder wall was measured at three points, of which the average was recorded as the bladder wall thickness (BWT). Since a significant decrease in blood flow with bladder distension was reported in animal [8,9] and elevated intravesical pressure could considerably affect the results of CDU, the bladder was filled with 100-200ml of saline to keep intravesical volume constant. Detection of arterial blood flow was obtained from three sites, the anterior bladder wall and the two lateral walls. Scanning was continued for 5min in each site, and the results were classified into 2 categories. BF (+) when blood flow was detected at any site and BF (-) when it was not. When pulsatile blood was detected, maximum (Vmax) and minimum (Vmin) blood velocities were measured by the pulsed-Doppler method, and resistive index was calculated (DRI = Vmax – Vmin / Vmax).

Values were expressed as the mean plus or minus standard deviation. An unpaired Student’s t-test was used to compare continuous variables between patients with and without BOO. Statistical analyses were performed with commercially available computer software. A p value <0.05 was defined as statistically significant.

Results

According to the pressure-flow study results, 18 patients (60%) proved to have BOO and 12 (40%) were unobstructed. The detection of blood flows was significantly more frequent in the obstructed group than in the non-obstructed group (p<0.001). The percentage of BF (+) and BF (-) was 88.9% (16/18) and 11.1% (2/18), respectively, in the obstructed group (Fig. 1). In contrast, the percentage of BP (+) and BF (-) was 25% (3/12) and 75% (9/12), respectively in the nonobstructed group (Fig. 2). As a result, BOO could be predicted with a diagnostic accuracy of 83.3% (25/30) using CDU (Table 1). In the control group blood flows were not detected in all men and the mean value of BWT was 2.8±1.1mm (Fig. 3).

Table (1): Diagnostic value of CDU in the prediction of BOO/BPH.

<table>
<thead>
<tr>
<th>Group</th>
<th>With BOO</th>
<th>Without BOO</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF (+)</td>
<td>16</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>BF (-)</td>
<td>2</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>12</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>88.9% (16/18)</td>
</tr>
<tr>
<td>Specificity</td>
<td>75% (9/12)</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>84.2% (16/19)</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>81.8% (9/11)</td>
</tr>
<tr>
<td>Diagnostic accuracy</td>
<td>83.3% (25/30)</td>
</tr>
</tbody>
</table>

Fig. (1): Ultrasound Doppler scan showing DRI of left lateral bladder wall in a 68 yrs old man with confirmed BOO. DRI = 0.78, average BWT = 4.86 mm.
Results of parameters in patients with and without BOO are presented in Table (2). A significant difference was noted in BWT and DRI followed by age, serum PSA levels and prostate volume.

Table (2): Comparison of parameters between benign prostatic hyperplasia patients with and without bladder outlet obstruction.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>With BOO (n = 18)</th>
<th>Without BOO (n = 12)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>69.2±6.7</td>
<td>62.1±5.2</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>PSA (ng/ml)</td>
<td>3.9±3.2</td>
<td>2.6±1.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Prostate volume (ml)</td>
<td>45.5±23.1</td>
<td>34.7±19.1</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>BWT (mm)</td>
<td>5.6±2.1</td>
<td>3.2±0.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DRI</td>
<td>0.82±0.07 (n = 16)</td>
<td>0.65±0.08 (n = 3)</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

Key: PSA = Prostate specific antigen; 
BWT = Bladder wall thickness; 
DRI = Detrussor resistive index.

Discussion

Bladder outlet obstruction is a common urologic diagnosis, and is reported to be the most common urologic problem faced by elderly male patients. The condition has many and varied etiologies and is frequently associated with an enlarged prostate gland. Because approximately one third of older men with LUTS/BPH don't have BOO, the clinical challenge for physicians is to identify patients with BOO before they enter widely variable and sometimes irreversible alterations in bladder contractility and/or compliance (10).

Urodynamics with PFS remain the gold standard for diagnosing BOO and other voiding and storage abnormalities. Although accurate, PFS is not without confounding variables (e.g., urethral catheter size, ability of the individual to void in the circumstances of the study, academic disagreement surrounding absolute and cutoff criteria for obstruction) (11). Therefore, other non invasive and/or minimally invasive ways of diagnosing BOO continue to be the subject of investigation.
Animal models of BOO, developed in the rat, guinea pig and rabbit, were instrumental in understanding the pathophysiology of bladder response to increased outlet resistance. Partial outlet obstruction results in a significant increase of bladder weight, neovascularization, and reduction of blood flow to smooth muscle fibers after an initial increase [12]. Saito et al. [13], using a rat urinary bladder obstruction model, suggested a linear correlation between the severity of obstruction and the degree of reduction in blood flow to the bladder.

In the last decade, remarkable improvements have been obtained concerning blood perfusion with the use of CDU, which has made it possible to evaluate the status of blood flow noninvasively in many organs. In the current study, CDU of the bladder wall was performed to test its clinical usefulness in diagnosing BOO due to BPH. We found that patients with BOO, as confirmed by pressure flow study, had significantly reduced detrusor blood flow compared with non-obstructed patients. Bladder outlet obstruction was detected with a diagnostic accuracy of 83.3%. Our results are consistent with those of Naya [6], who found CDU useful in predicting the cause of bladder hypertrophy and in detecting infravesical obstruction with an 80% diagnostic accuracy. Bellenky and Coworkers [7] also noted a significant correlation between DRI and PFS in 29 patients with BPH. They reported 86% overall accuracy rate of DRI in detecting BOO. Along similar lines, other researchers noted a significant correlation between the RI of the prostate (assessed by transrectal US) and PFS in patients with BPH [14,15].

Many investigators found that measurement of BWT provided high sensitivity and specificity values for the diagnosis of BOO and matched favorably with maximum flow rate measurement and uroflowmetry [16]. Similar results were reported by Oelke et al. [17]. Bladder wall thickness measurement is significantly influenced by bladder volume. Manieri et al. [16] circumvented the problem of bladder volume by measuring BWT at a volume between 100-200 mL during urodynamic procedures in adults. They found that BWT correlated with urodynamic parameters of obstruction. In the present study, BWT in patients with BOO was significantly greater (18 patients, 5.6±2.1mm) than that in the normal control group (10 men, 2.8±1.1 mm; p=0.001) or the nonobstructed group (12 patients, 3.2±0.9mm, p=0.001). Consequently, the combination of BWT measurement and CDU could be promising in predicting BOO.

Conclusions:
Although the number of patients is insufficient for a definitive conclusions, evaluation of detrusor blood flow by CDU is likely to be useful for the noninvasive evaluation of BOO/BPH. Additional studies are warranted to evaluate multiple ultrasonographic parameters like BWT, ultrasound estimated bladder weight, DRI, prostate RI and transition zone index in the management paradigm of patients with suspected BOO.

References


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