Clinical, imaging and cystometric findings of voiding dysfunction in children

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Abstract

The aim of the study was to validate some of the imaging criteria for voiding dysfunction in children.

Material and methods: The study included a number of 55 children with voiding dysfunction symptoms. They were investigated clinically as well as through imaging techniques: renourinary ultrasound, voiding cystourethrography and cystometry.

Results: The most common symptoms were urgency (87.3%), increased frequency (81.8%), and daytime urinary incontinence (76.3%). Ultrasound scans detected a reduced bladder capacity in 65.5% patients. The voiding cystourethrography detected bladder trabeculations (58.2%) and spinning top urethra (63.6%). Cystometric recordings indicated overactive bladder in 70.9% patients. Reduced bladder capacity detected by ultrasound associated with trabeculated bladder and spinning top urethra detected by voiding cystourethrography in a patient with specific symptoms may suggest an overactive bladder.

In conclusion, voiding dysfunction in child can be diagnosed by minimal or non-invasive methods.

Keywords: voiding dysfunction, child, ultrasound, spinning top urethra, cystometry.

Introduction

Voiding dysfunction manifests itself through an abnormal voiding pattern developed after the age of urinary control. The main symptoms are: urgency, frequency, daytime and nighttime incontinence, complaints that are usually associated with urinary tract infections. It is therefore mandatory to diagnose the condition as quickly as possible in order to reduce the social and psychological impact of urinary incontinence.

The evaluation of a patient with voiding dysfunction requires noninvasive methods of study. Most often the history, a clinical exam, ruling out a urinary tract infection and an ultrasound examination of the urinary tract before and after voiding along with an analysis of the bladder diary are enough for diagnosis. A voiding cystourethrography is necessary when there is a history of recurrent urinary tract infections or when the ultrasonographic findings demand it [1-4]. Advanced investigations including cystometry are limited for patients that do not respond to a properly conducted conservative treatment. Invasive cystometric studies, which are actually the gold standard for the diagnosis of the lower urinary tract dysfunctions, are uncomfortable, less available and expensive [5-6]. The present course of action is to replace the invasive investigations of these patients with noninvasive ones and to find new methods, sensitive enough for the evaluation of the voiding dysfunction, as an alternative to the invasive studies [7-8].

The objective of the study was to validate noninvasive or minimum invasive investigations as predictive for the type of voiding dysfunction that is usually diagnosed through cystometry.
Material and method

The study was a prospective observational study and was conducted in the 3rd Pediatric Department, Cluj-Napoca, between January 2005 and December 2009. A number of 55 patients with symptoms suggesting voiding dysfunction were included. An informed consent was obtained from the parents of the children, according to the regulations of the Ethics Committee of the Pediatric Hospital, Cluj-Napoca. There were 45 girls (81.8%) and 10 boys (18.2%) with a mean age of 9 years and 2 months.

The symptoms were represented by: urgency, daytime or nighttime incontinence, frequent or rare micturition. The patients with neurogenic bladder and organic subvesical obstruction were excluded from the study.

A complete history was taken and a clinical exam was performed to all the patients in the study group. Their bladder capacity was measured and compared to the normal bladder capacity for their age, according to the following formula: 

$$ BC = 30 + 30 \times \text{age (years)} $$

It was consider a normal bladder capacity the value that was calculated ± 20%. Additional investigations were performed in order to determine the presence of an associated urinary tract infection (urinalysis, urine culture) and to evaluate the renal function (serum creatinine). The imaging investigations performed to this group were represented by renourinary ultrasonography, voiding cystourethrography and cystometry.

Renourinary ultrasonography

The ultrasonographic examination was performed on a SA 6000 C ultrasound machine, using a multifrequency convex transducer, adapted for the patient’s age.

During the ultrasound exam the bladder capacity, the bladder wall thickness and the post-void residual volume were determined. The bladder capacity was calculated by obtaining three diameters: transverse, longitudinal and anterior-posterior. After voiding, the residual volume was calculated in the same way.

The bladder wall thickness was appreciated with the patient’s bladder in a state of repletion. A wall thickness under 4 mm was considered normal. Irregularities of the bladder contour, the presence of diverticula or pseudodiverticula were also evaluated.

Voiding cystourethrography

The examination was performed using a small, sterile catheter that was introduced into the bladder through the urethra. Iodinated contrast media (Urografin) diluted in saline solution was introduced with low pressure through a perfusion kit adapted to the catheter. The contrast media was introduced until the patient presented the urge to urinate. Then three radiographic films were obtained: before, during and after voiding. On the film obtained before voiding, the contour of the bladder was appreciated (smooth, trabeculated, with pseudodiverticula) and the presence of vesicoureteric reflux was evaluated (VUR). On the second film the aspect of the urethra was appreciated, as well as the changes noticed in the proximal part of the urethra (spinning top urethra, STU). On the after voiding film the presence of residual urine was evaluated and the presence of a vesicoureteric reflux that did not appear on the previous films.

Cystometry

The machine used in the study was one of indigenous production and it includes a multiple lumen catheter, a perfusion system, pressure transducers and a recording device. The capillaries of the catheter were perfused by a hydraulic pump with a perfusion debit of 0.5 ml/min/orifice. The manometer catheter was introduced through the urethra until the pressure sensors were placed in the bladder and a bladder baseline pressure was recorded. The bladder was then filled, using the same catheter, with saline solution warmed up to the body’s temperature. The filling debit was the physiological debit, defined by a value calculated by dividing the patient weight (in Kilos) to 4 and expressed in ml/min. In order to evaluate the pressure of the detrusor muscle a catheter was placed inside the rectum to determine the intra abdominal pressure. Then the pressure of the detrusor was calculated by subtracting the intraabdominal pressure from the intravesical pressure.

The obtained data was afterwards statistically analyzed using MedCalc 9.3.2.0. for Windows. The data was reported as arithmetic mean, 95% confidence interval (CI) or percentage. The univariate analysis of the studied parameters was performed using the Spearman test. The parameters that were individually associated with voiding dysfunction were analyzed through multiple regression. The statistical analysis searched for a statistically significant association between non-invasive and minimum invasive methods (ultrasonography and voiding cystourethrogram) compared with the diagnostic gold standard of voiding dysfunction, cystometry. In order to evaluate the validity of the method the sensitivity, specificity, positive predictive value, negative predictive value, probability ratio and ROC curves (receiver operating characteristic) were determined. A p value under 0.05 was considered statistically significant.

Results

The clinical and imaging characteristics found in the study group are listed in table I.

Except for the cases with rare micturition, the rest of the patients had a minimum of 2 voiding dysfunction symptoms.
The relationship between voiding dysfunction specific symptoms and the imaging aspects revealed by ultrasonography and voiding cystourethrography was evaluated. The Spearman test showed a statistically significant association between urinary urgency and frequency and the following imaging aspects: low bladder capacity measured by ultrasound (p=0.001), trabeculated bladder visualized on voiding cystourethrography (p=0.003), STU (p=0.02) and an association between the trabeculated bladder and STU (p=0.008).

Figure 1 and 2 present the ultrasound aspect of low bladder capacity and the STU appearance on a middle film cystourethrography of a 7 years old girl with voiding dysfunction.

Regarding the type of voiding dysfunction, in our study 70.9 % of the patients presented detrusor overactivity, 10.9% detrusor underactivity and the rest of the patients had normal cystometric findings.

The low bladder capacity determined by ultrasound was independently associated with voiding dysfunction.

After analyzing the parameters and the ROC curves it was noticed that both, low bladder capacity, appreciated by ultrasound and bladder trabeculations, visualized by cysto-urethrography, accompanied by STU, associate in a statistically significant manner with detrusor overactivity determined by cystometry.

Table III shows a comparative presentation of the data obtained after the ultrasonographic and cystourethrographic parameter analysis versus cystometry.
Table II. Multiple regression analysis of the factors associated independently with voiding dysfunction

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation „r” index</th>
<th>Standard Error</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low bladder capacity measured by ultrasound</td>
<td>0.49</td>
<td>0.09</td>
<td>0.004</td>
</tr>
<tr>
<td>Trabeculated bladder walls on voiding cystourethrography</td>
<td>0.41</td>
<td>0.12</td>
<td>NS</td>
</tr>
<tr>
<td>STU on voiding cystourethrography</td>
<td>0.34</td>
<td>0.13</td>
<td>NS</td>
</tr>
<tr>
<td>Trabeculated bladder walls and STU on voiding cystourethrography</td>
<td>0.39</td>
<td>0.17</td>
<td>NS</td>
</tr>
</tbody>
</table>

p= 0.001

Table III. Comparative aspects of the investigation techniques used in the voiding dysfunction in children: bladder ultrasonography and voiding cystourethrography versus cystometry.

<table>
<thead>
<tr>
<th></th>
<th>LBC</th>
<th>CB</th>
<th>STU</th>
<th>STU+ CB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se (%) (95% CI)</td>
<td>89.7 (75.8-97.1)</td>
<td>74.3 (57.9-86.9)</td>
<td>71.8 (55.1-85)</td>
<td>79.5 (63.5-90.7)</td>
</tr>
<tr>
<td>Sp (%) (95% CI)</td>
<td>56.2 (29.9-80.2)</td>
<td>81.2 (54.3-95.7)</td>
<td>56.2 (29.9-80.2)</td>
<td>56.2 (29.9-80.2)</td>
</tr>
<tr>
<td>LR+</td>
<td>2.05</td>
<td>3.97</td>
<td>1.64</td>
<td>1.82</td>
</tr>
<tr>
<td>LR-</td>
<td>0.18</td>
<td>0.32</td>
<td>0.50</td>
<td>0.36</td>
</tr>
<tr>
<td>PPV</td>
<td>83.3</td>
<td>90.6</td>
<td>74.4</td>
<td>81.6</td>
</tr>
<tr>
<td>NPV</td>
<td>69.2</td>
<td>56.5</td>
<td>80</td>
<td>52.9</td>
</tr>
<tr>
<td>AUROC (95% CI)</td>
<td>0.73 (0.59-0.84)</td>
<td>0.78 (0.65-0.88)</td>
<td>0.64 (0.50-0.76)</td>
<td>0.67 (0.53-0.79)</td>
</tr>
<tr>
<td>SE (95% CI)</td>
<td>0.07 (0.65-0.88)</td>
<td>0.07 (0.50-0.76)</td>
<td>0.07 (0.53-0.79)</td>
<td>0.07 (0.50-0.76)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>70.9</td>
<td>70.9</td>
<td>70.9</td>
<td>70.9</td>
</tr>
<tr>
<td>p</td>
<td>0.001</td>
<td>0.0001</td>
<td>NS</td>
<td>0.01</td>
</tr>
</tbody>
</table>

LBC – low bladder capacity determined by ultrasound; TB – trabeculated bladder visualized on voiding cystourethrography; STU – spinning top urethra; Se – sensitivity; Sp – specificity; CI – confidence interval; LR+ – likelihood ratio for a positive result; LR- – likelihood ratio for a negative result; PPV – positive predictive value; NPV – negative predictive value; SE – standard error, AUROC – the area under a ROC curve.
Discussions

Changes in the voiding pattern are frequently encountered during childhood. A clinical exam and a minimum of investigations are most often enough to establish an adequate treatment of these symptoms.

Voiding dysfunction symptoms are represented by urgency, frequency and incontinence. In the present study urgency was reported in 87.3% of the cases, daytime incontinence in 76.3%, enuresis in 47.2%, and frequency in 81.8%. Studies performed on larger groups show that the most frequently encountered symptom of voiding dysfunction is urgency (between 52 and 87%). Associated to it, daytime and nighttime incontinence are present in up to 77% [1,9-12].

The most important imaging investigations for these patients are represented by urinary tract ultrasonography and voiding cystourethrography. Cystometry remains the most reliable method of investigation of bladder filling phase. But cystometry is an invasive method and it is considered useful especially in those cases where the classic therapy does not lead to a favorable outcome [13-15].

Ultrasonography of the inferior urinary tract evaluates the bladder capacity, the bladder contour and the post-void residual volume. In most cases voiding dysfunction manifests by low bladder capacity, irregular contour of the bladder and post-void residual urine [7,16-18]. In the present study the low bladder capacity was found in 65.5% of the patients and post-void residual urine in 36.3% of the patients.

The voiding cystourethrography of the patients enrolled in the study revealed the presence of low degree vesicoureteric reflux (I-III) in 12.7% of the cases, a percentage similar to the ones found in literature [19-22].

The most frequent complaints of the patients with voiding dysfunction were significantly linked with the imaging findings.

Literature data demonstrates the presence of spinning top urethra in patients with voiding dysfunction. We found a statistically significant association between these patients and the presence of STU (p = 0.01). Batista et al. performed a study on 59 patients, divided into 2 groups, one with voiding dysfunction and overactive bladder and one control group. Both groups underwent cystourethographic and cystometric investigations. The study demonstrated that 51% of the cases with voiding dysfunction presented STU and bladder trabeculations on the voiding cystourethrography. The positive predictive value was high (0.89), but the diagnostic value of these radiographic signs was low because the sensitivity (50%), the specificity (62%) and the global accuracy were low [23].

Spinning top urethra was found in 63.3% of the patients enrolled in our study, a result concordant with the literature data [22,24-28].

A trabeculated wall of the bladder, as a sign of voiding dysfunction, was present in 58.2% of the cases, with a statistically strong association between this imaging aspect and the patient’s symptoms (p=0.003).

The cystometric studies performed on the patients in the study group showed detrusor overactivity in 70.9% of the situations. Even though cystometry represents the gold standard method for the diagnosis of voiding dysfunction, there are other, less invasive, imaging investigations that can be used for diagnosis. Therefore, the presence of low bladder capacity for the patient’s age determined by ultrasound, the trabeculated bladder visualized on the cystourethrography and the association of trabeculated bladder and STU on the cystography in a patient with specific symptoms of urinary urgency and frequency may be suggestive for detrusor overactivity (sensitivity 89.7%, 74.3% and 79.5%, specificity de 56.2%, 81.2% and 56.2%, positive predictive value 0.83, 0.90 and 0.81 positive probability ratio 2.05; 3.97 and 1.82). The study of Ramamurthy et al [6] was performed on 41 patients and aimed for the validation of non-invasive tests that could predict the type of voiding dysfunction normally diagnosed by cystometry revealed that an association of various non-invasive investigations could predict the bladder overactivity determined by cystometry. Therefore the presence of urinary incontinence accompanied by postponing micturition, recurrent urinary tract infection, low bladder capacity measured by ultrasound and low bladder capacity associated with a cystourethographic aspect of STU may be consistent with the bladder overactivity determined through the gold standard method. Since the number of cases in the study was low, the sensitivity of the study was 88.4%, the specificity 72.7%, the positive predictive value was 0.99 and positive probability ratio 3.2 [6].

The low number of patients included in the study represents the main limit of this study, but even so the findings were consistent with literature data.

Recent literature data emphasizes the role of ultrasonography in the evaluation of the patients with lower urinary tract symptoms. Today, ultrasonography may be viewed as an attractive alternative to the other invasive investigations. Dynamic ultrasonography of the bladder represents a sensitive method in the assessment of voiding dysfunction, opening new perspectives in its diagnosis. It allows a natural appreciation of the bladder capacity, of the post-void residual volume and of the involuntary contractions of the detrusor muscle, accompanied or not by urinary incontinence. Furthermore, the advantages of the method are also represented by the full cooperation of the patient, no use of catheters like the ones used for cystometry and a physiologic filling of the bladder. Filgueiras
et al showed that ultrasound, compared with urodynamic studies has 100% sensitivity, a 97.8% specificity, a 96% positive predictive value and a 100% negative predictive value in detecting involuntary contractions of the detrusor muscle accompanied by urinary incontinence [18].

Ozawa et al described in 2010 a new transperineal urodynamic technique using Doppler ultrasound. This method has the advantage of being fast, effective and completely noninvasive [29].

The management of overactive bladder remains a conservative one, with minimum adverse reactions (scheduled micturition and anticholinergic medication), while the gold standard investigation is only required in cases of therapy failure.

**Conclusion**

The presence of voiding dysfunction symptoms accompanied by low bladder capacity measured by ultrasound and bladder trabeculations and STU may suggest the presence of detrusor overactivity.

**Conflict of interest:** none

**References**


